International Journal of
Environmental Research
and Public Health

New Developments in Physical Education and Sport

Edited by
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Printed Edition of the Special Issue Published in
International Journal of Environmental Research and Public Health

www.mdpi.com/journal/ijerph

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Editor

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This is a reprint of articles from the Special Issue published online in the open access journal *International Journal of Environmental Research and Public Health* (ISSN 1660-4601) (available at: https://www.mdpi.com/journal/ijerph/special_issues/new_developments_physical_education_sport).

For citation purposes, cite each article independently as indicated on the article page online and as indicated below:

LastName, A.A.; LastName, B.B.; LastName, C.C. Article Title. *Journal Name* **Year**, *Volume Number*, Page Range.

ISBN 978-3-0365-0244-1 (Hbk)
ISBN 978-3-0365-0245-8 (PDF)

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About the Editor

Antonio Granero-Gallegos, Ph.D., Associate Professor at the University of Almeria (Spain). He is a teacher of the Faculty of Educational Sciences and is also presently the coordinator of Degree in Sciences of Physical Activity and Sports and secretary of Health Research Center. He has 24 years of teaching experience at different educational levels and has researched various topics for 17 years, mainly about motivational variables related to teaching and learning processes in physical education and sport, physical activities in the natural environment, and body image. To date, he has published more than 120 papers in scientific journals indexed in the Web Of Science (WOS). h-index: 15 (WOS).

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Editorial

New Developments in Physical Education and Sport

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Received: 30 November 2020; Accepted: 7 December 2020; Published: 8 December 2020

1. Introduction

Continuous updates of knowledge among professionals in physical education (PE) and sport are essential for the goal of developing quality professional work. In our current globalized and changing world, continuous and permanent learning is fundamental for organizing and complementing initial training and previous experience.

To ensure competence in the field of PE and sport, it is important to have a proactive attitude towards the extensive knowledge arising from continuous research and to integrate it with one's prior knowledge and work experience. This is the path to career improvement and satisfaction. Certainly, research is an unfinished and diverse construct: it is a permanent learning process in terms of interpretations, explanations, and contributions.

Globalization, research, and education must respond to continuous changes in the different spheres of social, economic, and scientific activity. Information and communication technologies provide excellent mechanisms to facilitate the study, exchange, and dissemination of principal research findings regarding knowledge and knowledge socialization events. For this reason, and to develop competence or learning, it is also necessary to select the most appropriate information as well as quality publications that are produced with methodological rigor. Integrating knowledge in a way that can be suitably applied in the modern setting will help us to flourish as highly competent professionals in PE and sports, a field that is increasingly taken up by the population.

The Current Special Issue

This Special Issue was proposed in order to compile some of the latest research advances in the PE field and to evaluate the relationship of different variables with physical activity behaviors outside the classroom. Improving teaching processes and understanding the different psychological variables that affect learning are of continuous concern among the different agents involved in teaching. This is highlighted by the wide range of articles in the educational context (primary, secondary, and higher education) that focus on such issues as innovative teaching methodologies, pedagogical models, motivation, satisfaction and frustration of basic psychological needs, perfectionism, self-esteem, motivational climate, and emotional intelligence.

This issue also includes research on different aspects for promoting moderate and vigorous physical activity in students, both inside and outside of the educational center, and for creating healthy and permanent physical exercise habits in the future. Similarly, research focused on activities in nature, recreational pursuits, and sports tourism have been published, with samples comprising students and healthy adults.

Numerous and varied articles on the practice of physical activity and sports by special populations are featured in this Special Issue. On the one hand, we explore studies carried out in different sports contexts, such as those conducted on football players, young professional athletes, handball referees, and professional endurance athletes. On the other hand, we include studies on special populations such as elderly people; these articles show the importance of leading an active life or are focused on the most avant-garde technological advances in physical activity, such as a pro-device for monitoring physical activity and movement.

The progress made in adapting measurement instruments is also assessed in this Special Issue, especially the implications of their use for future research; four articles that focus on different characteristics of instruments' psychometric properties have been published. Furthermore, in recognition that physical and sports education of high quality must be offered to society and must increasingly be based on empirical scientific evidence, this Special Issue also includes articles that report systematic review and meta-analysis, as well as studies that use experimental and quasi-experimental methodologies.

The topics covered by the articles are diverse, as are the methodologies used, and we are pleased that new developments in PE and sport have aroused interest in the scientific community. Our aim is to contribute to advances of the scientific debate and to provide a quality update for different professionals in this field.

2. The Studies Included

We received a total of 42 submissions, of which 28 were ultimately accepted. The submission process was open from October 2019 to September 2020. As readers will see, most of the accepted publications used cross-sectional methodologies, although qualitative, experimental, quasi-experimental, and meta-analytical studies were also included, along with psychometric instrument validations and systematic reviews. The majority of the studies were conducted in Spain, although some studies were conducted in populations from Taiwan, Poland, Luxembourg, Germany, Turkey, Lithuania, Croatia, Mexico, and Portugal.

Presented in chronological order of publication, this Special Issue includes the papers described below.

Trigueros, Aguilar-Parra, López-Liria, and Rocamora [1] used structural equation modeling to analyze the influence of several psychological control variables on emotional intelligence in a large sample of 1602 secondary school students. They also examined the meta-cognitive strategies employed by students with regard to emotional intelligence and the thwarting of basic psychological needs. Their results showed that psychological control positively predicted each of the sub-factors related to the thwarting of psychological needs, whereas the thwarting of psychological needs negatively predicted emotional intelligence, and emotional intelligence positively predicted meta-cognitive thinking. As the authors note, this research supports the tenets of self-determination theory, viewed from the darker side, while introducing new variables and demonstrating their applicability to Spanish culture.

Granero-Gallegos, Ruiz-Montero, Baena-Extremera, and Martínez-Molina [2] used multi-level regression models to analyze the effects of perceived teaching competence, motivation, and basic psychological needs on disruptive behaviors in secondary school PE students. Their results revealed that disruptive behaviors were more likely to occur among boys and that misbehavior decreased when a teacher was perceived as competent. Furthermore, students with greater self-determined motivation were more likely to exhibit fewer behaviors related to low engagement and irresponsibility, whereas amotivation increased various disruptive behaviors in the classroom.

Fuentesal-García, Baena-Extremera, and Sáez-Padilla [3] carried out two different research studies to analyze the psychometric properties of the Physical Activity Enjoyment Scale applied to different contexts, for initial or original use, such as physical activity in nature. This included a confirmatory factorial analysis. The authors concluded that this scale could not be applied as-is in the studied context and that certain items had to be eliminated and/or modified. From this work, they obtained a new specific instrument for this type of practice.

Hinojo, López, Fuentes, Trujillo, and Pozo [4] carried out experimental research on flipped learning as an innovative approach to physical education teaching and learning processes. The authors evaluated the effectiveness of flipped learning compared with the traditional methodology. Two study groups were established: control (traditional methodology) and experimental (flipped learning) groups at each educational stage (primary and secondary education). The results showed that the experimental group scored higher than the control group in academic indicators, motivation, autonomy, and interactions between different agents.

Abad, Collado-Mateo, Fernández-Espínola, Castillo, and Fuentes-Guerra [5] conducted a systematic review with a meta-analysis of the effects of technical and tactical intervention approaches on skill execution and decision-making, and they examined the influence of the teacher/coach management style. This study was performed following PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) using the Web of Science (WOS), PubMed (Medline), Scopus, and SportDiscus electronic databases. The meta-analysis results showed that tactical interventions achieved significant decision-making improvements, but they did not significantly improve skill execution compared with technical approaches. Tactical approaches are recommended for teaching games and sports in order to develop technique, understanding, tactical knowledge, and decision-making, all of which are required in gameplay.

García-Angulo, Palao, Giménez-Egido, García-Angulo, and Ortega-Toro [6] performed a quasi-experimental study on under-12 male football players to analyze the effect of reducing the number of players, the size of the goal, and the size of the playing space on the technical and tactical actions of young football players. The authors concluded that using modified rules generated a greater number of and more variability in technical–tactical actions, a greater number of actions with teammates in the pass line, greater continuity throughout the game, and more attacking and defensive actions close to the goal. This strategy also favored team play.

Trigueros et al. [7] took the version of the Scale of Basic Psychological Needs tailored to the physical exercise context and adapted it to and validated it in the Spanish PE context, with the important incorporation of novelty into the scale. In total, 2372 people took part in the research, and several analyses were performed. The results were reported for both the eight-factor structure and the higher-order double model, in which the eight subscales were joined into two constructs called frustration and satisfaction. The factorial structure of both models was invariant with respect to gender and age.

Sánchez-Oliva et al. [8] analyzed the relationships between perceived need support and need satisfaction with self-determined motivation and extracurricular physical activity intentions in the PE classroom, with sex and out-of-school sport participation included as moderators. Using multi-level analysis, the authors concluded that, at the classroom level, males benefited from need-supportive classes more than females in terms of increased autonomous motivation, whereas females benefited more than males in terms of decreased amotivation. Perceived need support at the class level moderated the negative association between need satisfaction and amotivation and between amotivation and intentions. The findings suggest that a need-supportive classroom environment may play an important role in students' motivation and behavior.

Burgueño and Medina-Casaubón [9] performed a cluster-randomized controlled trial with 148 high school students (sport education group, $n = 74$; control group, $n = 74$) to assess the influence of sports education on sportsmanship orientations. The multivariate analysis showed significant multivariate effects at the level of each sportsmanship orientation between both groups, in favor of the sports education group. The authors concluded that sports education is an effective pedagogical model that should be considered by PE teachers for optimally promoting the moral and ethical education of high school students via the development of sportsmanship orientations in the context of school PE.

Tornero-Quiñones, Sáez-Padilla, Espina, Abad, and Sierra [10] carried out a study on 139 older people (between 65 and 87 years of age) to analyze the differences in autonomy between an active group (69 people) and a sedentary group (70 people) in terms of both basic daily activities and instrumental daily activities, as well as in functional capacity, fragility, and fall risk. By means of multivariate analysis, the authors found that the active group presented better values than the sedentary group, with statistically significant differences in all variables evaluated. Moreover, in the active group, functional capacity was a positive predictor variable of autonomy in instrumental daily activities, while fragility and fall risk were significant positive predictors of autonomy in basic daily activities. The importance of leading an active life after retirement is demonstrated once again.

García-Ceberino, Gamero, Feu, and Ibáñez [11] carried out quasi-experimental research to compare the declarative and procedural knowledge acquired by two groups of fifth-year students after implementing two intervention programs in school football: The Tactical Games Approach vs. the Direct Instruction Model. The results revealed no significant intergroup differences with regard to the methodology applied.

Muñoz-Villena, Gómez-López, and González-Hernández [12] analyzed psychological variables in 229 young male athletes from professional youth sport teams to evaluate the differences in anger expression and management according to self-esteem and perfectionism indicators. The results showed that high personal standards predicted lower anger trait indicators for athletes with low self-esteem. The results also revealed that high self-esteem acted as a protective factor in the predictive relationship between anger traits and personal standards. The study described the relationship between these variables and the young male footballers' sense of belonging (under a high level of sports pressure). Their results highlight the need to foster athletes' self-esteem in sports environments through prevention programs that include psychological and social resource training systems.

Thomas et al. [13] performed a randomized controlled trial in several European countries to assess whether an enriched sports activity program could increase physical fitness in a population of schoolchildren. The intervention group performed an additional warm-up protocol, which included cognitive-enhancing elements over 14 weeks, while the control group continued with the standard exercise activity. In the experimental group, the intragroup analysis (pre and post-test) showed a significant increase in the 1 kg and 3 kg ball throw, the standing broad jump, the 30 m sprint, and the Illinois agility test, while no significant differences were found in the quadruped test or the Léger shuttle run. In the control group, intragroup analysis (pre and post-test) showed no differences for any test except for the quadruped test and the Léger shuttle run.

Rodríguez-Medellín et al. [14] adapted and validated the Engagement and Disaffection Scale to the PE context in Mexico and assessed its reliability, factorial structure, and factorial invariance by gender on a sample of 1470 elementary school students. Confirmatory factor analysis, factorial invariance, internal consistency, correlations, and convergent and discriminant validity were performed. The authors concluded that the Mexican version of this scale is valid and useful for measuring these constructs in the PE context.

Noguera, Carmona, Rueda, Fernández, and Cimadevilla [15] carried out a quasi-experimental study with a recreational sample (48 healthy adults organized into two groups: 26 non-professional salsa dancers and 20 non-dancers) to evaluate whether dancing, as a physical activity that includes a lot of jumping and turning, affects spatial memory and executive functions. To do this, they used sensitive virtual reality-based tasks and the ANT-I task (Attentional Network Test-Interactions) to assess spatial memory and executive functions, respectively. Dancing integrates physical activity with music and involves the memory retrieval of complex step sequences and movements to create choreographies. The conclusion suggests that dancing can be a valid approach to slowing natural age-related cognitive decline. However, since dancing combines several factors, such as social contact, aerobic exercise, cognitive work with rhythms, and music, it is difficult to determine the weight of each of the variables analyzed.

Amado, León-del-Barco, Mendo-Lázaro, and Iglesias [16] performed a cross-sectional study with 944 school children to examine how body image satisfaction and gender can act as modulating variables on emotional intelligence in childhood. They analyzed differences in the intrapersonal, interpersonal, stress management, adaptability, and mood dimensions of emotional intelligence according to the degree of body image satisfaction and the children's genders. The results revealed that children who were satisfied with their body image exhibited higher interpersonal intelligence, greater adaptability, and better mood; in addition, girls outperformed boys in stress management. The authors emphasized the need to promote campaigns designed by specialists to prevent body image dissatisfaction and to ensure that the benefits are able to reach the entire educational community (students, teachers, and parents). In this paper, several possibilities are described for meeting the demands of contemporary society.

Yang, Chuang, Lo, and Lee [17] propose a novel two-stage multi-criteria decision-making (MCDM) model that incorporates the concept of sustainable development into sports tourism. For this purpose, the authors carried out the Bayesian best–worst method (Bayesian BWM) to screen for important criteria and used a laboratory evaluation technique to map out complex influential relationships. To demonstrate the model's effectiveness, it was tested in central Taiwan. The results showed that the quality of urban security, government marketing, business sponsorship, and mass transit planning were the most important criteria. Together with local festivals, this was the most influential factor overall for the evaluation system.

Pérez-Pueyo, Hortigüela-Alcalá, Hernando-Garijo, and Granero-Gallegos [18] carried out a qualitative study to propose the attitudinal style as a pedagogical model in PE. First, they defined the characteristics and elements that make up the attitudinal style as a pedagogical model; second, the authors analyzed the perceptions of future teachers regarding the usefulness and transferability of the model in their classes. The results revealed that future PE teachers considered this model to be a transcendental methodological tool for understanding and addressing PE at school. Interpersonal relationships in the classroom, student autonomy, and group responsibility were highlighted as necessary aspects with high transferability to the school.

Oliva-Lozano, Martín-Fuentes, and Muyor [19] analyzed the validity and reliability of an inertial device for monitoring the range of pelvic motion during simulated intercourse and then compared the results with those of a gold standard system. Twenty-six adults took part and were monitored during simulated intercourse using an inertial device (WIMU) and a motion capture system (gold standard). The authors concluded that WIMU could be considered a valid and reliable device for monitoring the in–out cycle range of motion during sexual intercourse in the missionary and cowgirl positions.

Conejero, Prado, Fernández-Echeverría, Collado-Mateo, and Moreno [20] performed a systematic review with meta-analysis to evaluate the scientific literature on the effect of decision training interventions/programs from a cognitive perspective on the decision-making capabilities of volleyball players. This research was carried out following PRISMA guidelines, and studies were accessed through the WOS, Pubmed (Medline), Scopus, SportDiscus, and Google Scholar databases. From the results, the authors recommend using decisional interventions or training, both as part of normal active training and as a complement to it, in order to improve players' decision-making capabilities.

Płoszaj, Firek, and Czechowski [21] emphasized the role of referees as educators and suggested that they be taken into account when researching the educational value of sports among the youngest participants. This study was conducted on a group of 25 handball referees to analyze the quality of their interactions (a positive climate, responsiveness, behavior management, proficiency, instructing, communicating) with young players during handball matches. The authors concluded that the referees should be trained to foster a positive climate on the sports field by creating emotional ties with players (physical proximity, social conversation) while expressing an enthusiastic attitude and the joy of contact.

Kokkonen, Gråstén, Quay, and Kokkonen [22] performed structural equational modeling based on the self-reports of 363 fourth to sixth graders to analyze how students' perceptions of their psychological environment (i.e., the motivational climate in PE) contributed to their adoption of moderate to vigorous physical activity (MVPA) via their social competence and physical activity motivation. The results showed that both the motivational climate and co-operational aspect of social competence played significant roles in students' physical activity motivation, physical activity intention, and MVPA. Thus, the analysis of creative PE highlights that teaching behaviors contribute to students' MVPA through motivational climates, co-operation, physical activity motivation and physical activity intention.

Carrasco-Poyatos, González-Quílez, Martínez-González-Moro and Granero-Gallegos [23] proposed a protocol study for a cluster-randomized controlled trial to assess changes in the performance of high-level athletes after a heart rate variability (HRV)-guided training period or a traditional training period and to determine the differences in athletes' performance after both training protocols (follow-up after 12 weeks for the cluster-randomized controlled protocol, control group, and HRV group). The variables measured were the maximum oxygen uptake (VO_{2max}), the maximum speed (in m/s), the maximum heart rate, the respiratory exchange ratio, ventilatory thresholds (VT1 and VT2), and their derived speed, heart rate, respiratory exchange ratio, and VO_2 in an incremental treadmill test. To date, no other HRV-guided training research has been conducted on these types of professional athletes. It is expected that this HRV-guided training protocol will improve functional performance in high-level athletes, achieve better results than a traditional training method, and thus provide an effective strategy for coaches of high-level athletes.

Cattuzzo et al. [24] carried out a systematic review to examine studies that have assessed the performance of the supine-to-stand (STS) task in young people, adults, and the elderly. The databases accessed in the search were MEDLINE/Pubmed, Scielo, EMBASE, Scopus, ERIC/ProQuest, WOS, Science Direct, EBSCO, and Cochrane. After a qualitative analysis of the 37 studies included, the paper concluded that the STS task appears to be a universal tool for tracking functional motor competence and musculoskeletal fitness throughout life for clinical or research purposes.

Hutmacher, Eckelt, Bund, and Steffgen [25] performed a longitudinal study on 1681 students from elementary and high school in the context of PE. The measured variables were perceived need for support in PE, motivational regulation during PE, leisure time, attitude, subjective norm, perceived behavioral control, intention, and physical activity behavior. The main findings, based on mixed-effect models, revealed that the autonomy, competence, and relatedness support given by the PE teacher was positively related to autonomous motivation. In addition, longitudinal mediation analyses further supported the impact of autonomous motivation on physical activity, mediated by intention, attitude, and perceived behavioral control.

Ávalos-Ramos and Martínez-Ruiz [26] designed a qualitative study with 38 students who were in the first year of a bachelor's degree in Physical Activity and Sport Sciences of a Spanish university and were enrolled in the Gymnastic and Artistic Skills course. The methodological design consisted of 13 practical learning sessions on the subject mentioned, in which a support strategy for autonomy in collaboration was implemented. The learning process was carried out in three phases (initial, progress, and final). The evolution of motivation, autonomy, collaboration, and achievements was highly valued throughout the process. The final assessment caused pressure and anxiety in the students, thus decreasing self-control, impairing action, and distorting the motivation experienced during the learning process.

Granero-Gallegos, González-Quílez, Plews, and Carrasco-Poyatos [27] performed a systematic review with meta-analysis to analyze the effect of HRV-guided training on VO_{2max} in endurance athletes. The methods were reported in accordance with the Campbell Collaboration policies and guidelines for systematic reviews. The register contained studies identified from the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, CINAHL Complete, the Web of Science Core Collection, Global Health, Current Contents Connect, and the SciELO Citation Index. The results showed that HRV-guided training and control training enhanced the athletes' VO_{2max} ($p < 0.0001$), but the effect size (ES) for the HRV-guided training group was significantly higher. The amateur level and female subgroup produced better and significant results ($p < 0.0001$) for VO_{2max}. HRV-guided training had a small (ES = 0.402) but positive effect on endurance athlete performance (VO_{2max}), conditioned by the athlete's level and sex.

Finally, Baños, Fuentesal, Conte, Ortiz-Camacho, and Zamarripa [28] carried out a probabilistic study on secondary school students in Mexico to analyze the mediating effect of satisfaction/enjoyment and boredom between the perception of autonomy support and academic performance in PE. The mediating effect was examined using the PROCESS V.3.5 macro. The main findings revealed that autonomy support was not a direct indicator of PE performance; instead, a forecast of positive PE performance only occurred if students felt satisfied with PE. Satisfaction with PE had a mediating effect between autonomy support and PE performance. However, boredom did not have a mediating effect between autonomy support and the student's performance in the PE class.

3. Conclusions

In summary, these papers add to our understanding of the latest advances and developments in PE and sport. Through the 14 articles that analyze the educational context at different stages, from elementary school to university, the concerns of the different agents that intervene in the teaching–learning process are assessed. Two articles also focus on motivational aspects, executive functions, and spatial memory performance in relation to the practice of physical activity during leisure time. An analysis of physical activity in elderly people is also presented to address concerns such as functional capacity, frailty, and fall risk. Two articles focus on physical activity in nature and sports tourism, while another study validates the most advanced technological applications in sport and the analysis of human movements, such as the WIMU pro-device. Four papers analyze different aspects in the field of sport: football, athletes in professional youth teams, handball referees, and professional endurance athletes (runners). Finally, four systematic reviews (two with meta-analyses) explore different questions related to sports education, volleyball players, healthy individuals, and endurance athletes.

Conflicts of Interest: The author declares no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

The Dark Side of the Self-Determination Theory and Its Influence on the Emotional and Cognitive Processes of Students in Physical Education

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Received: 25 October 2019; Accepted: 8 November 2019; Published: 12 November 2019

Abstract: Amongst the main objectives of physical education (PE) classes is the consolidation of healthy lifestyle habits in young people and adolescents. Nonetheless, these classes can also provide the basis from which adverse experiences are generated which affect students' perceptions of these classes. Previously conducted studies have focused on motivational processes and not on emotional processes, nor on the way in which students learn. The objective of the present study was to explore the dark side of the self-determination theory, its influence on emotional intelligence and the meta-cognitive strategies of students. Methodology: A total of 1602 young people undertaking secondary education participated, with self-reported ages between 13 and 19 years. The following questionnaires were utilized: *Controlling Coach Behaviors Scale, Frustration of Psychological Needs in PE classes Scale, Emotional Intelligence in PE Scale and Motivated Strategies for Learning Questionnaire.* A structural equation model was developed which explained causal associations between the study variables. Results: Psychological control positively predicted each one of the sub-factors of frustration of psychological needs. Frustration of psychological needs negatively predicted emotional intelligence. Finally, emotional intelligence positively predicted meta-cognitive thinking. Conclusions: The influence and importance of the teaching style adopted by teachers is indicated, in addition to the effect of students' psychological experiences on emotions and learning strategies.

Keywords: teacher psychological control; psychological need frustration; emotional intelligence; meta-cognitive strategies; physical education

1. Introduction

Despite the physical, psychological, and emotional benefits provided by regular engagement with physical activity (PA), only 20% of adolescents worldwide participate in a habitual way [1]. For this reason, Physical Education (PE) classes can contribute to resolving this problem, given that one of its fundamental objectives is the adoption of healthy lifestyle habits, such as engagement with regular extra-curricular PA [2]. However, for PE students to internalize these habits and the benefits they produce, it is necessary that pupils commit information to memory in an ordered way. This favors information recovery and means it can be applied within other similar contexts. This aspect is known as learning transfer [3]. Current studies principally focus on the motivational processes of students and their transfer towards PA [4]. Specifically, the self-determination theory (SDT) has been applied to the positive aspects of psychological processes, neglecting the negative aspects. In this sense, it is indicated that PE classes may also generate the adoption of maladaptive behaviors by students, above all when faced with unpleasant experiences [5]. Further, few studies exist that have considered the influence of emotions and the learning strategies employed by students during PE classes. For this reason, the present study seeks to explore the influence of the SDT on emotional intelligence and meta-cognitive strategies, taking a more critical perspective.

The SDT [6] suggests that the social context can influence individuals through the presence of two very different interpersonal styles within it. One of these is autonomy supportive, whilst the other is highly controlling. The first of these marks the beginning of the light perspective. It refers to teacher promotion of personal initiative, self-regulation and self-concept in students, with all of these making minimum use of contingencies [7]. On the other hand, the controlling style marks the beginning of the dark side. It refers to the application of external pressures by teachers and the use of coercive means, impositions, etc. These are perceived by students and form the origin of their behaviors, undermining their personal initiative, effort, and personal self-knowledge [8]. In this way, teachers will influence the psychological need development of their students, with the type of influence depending on the role they choose to adopt [9].

According to the SDT, psychological needs are basic and essential nutrients for development and personal wellbeing [10]. In this sense, there are three psychological needs: Autonomy (the extent to which an action carried out by an individual comes from their own interests), competence (the feeling of ability and of executing a task to a certain level), and relatedness with others (the feeling of ability and of executing a task to a certain level) [11]. Further, a study conducted by González-Cutre, Sicilia, Sierra, Ferriz, and Hagger [12] proposed the incorporation of novelty as a psychological need. This is defined as the innate tendency of an individual to seek new activities and experiences in order to achieve complete development and wellbeing. In this way, students who feel more autonomous when they participate in decision making feel supported and integrated within their reference social group, and will also be more competent when they carry out relevant actions. Those who consider the activities they engage in to be different and engaging will experience psychological need satisfaction. This represents the normal path when considering SDT from the light perspective. It is related with the learning of new abilities, commitment to learning, improved interpersonal relationships and engagement in adaptive behaviors [6]. In exchange, outcomes will be negative if, during PE classes, students experience feelings of abandonment, limited success from their actions, lack participation in decision making and judge actions to be excessively monotone or repetitive. These students will instead experience frustration of their psychological needs, this being the route understood by the dark side. This is related with abandonment of the activity, lack of commitment, a deficit in interpersonal relationships and, ultimately, manifestation of maladaptive behaviors [13].

Multiple studies have analyzed the influence of teachers and of the psychological needs of students from the tenants of the SDT, in the educational context of PE [4,14,15]. However, the majority of these studies have taken their focus from the light side of the SDT, with few studies available that have conducted their analysis taking the dark side. This discrepancy is even more evident if only studies conducted in the Spanish context are considered. In this sense, one study carried out by Baena-Extremera, Gómez-López, Granero-Gallegos, and Martínez-Molina [16] analyzed the extent to which autonomy acted as a predictor of enjoyment, learning climate, and the psychological need of autonomy in secondary school students. In the same way, Taylor and Lonsdale [17] showed that autonomy supportive teachers positively influenced the satisfaction of psychological needs, effort, and vitality in students during PE classes. Further, Zhang, Solmon, Kosma, Carson, and Gu [18] concluded that autonomy support was positively associated with satisfaction of the psychological needs (autonomy, competence, and relatedness with others), intrinsic motivation and intention to be physically active. Taking the dark side, a study conducted by Haerens, Aelterman, Vansteenkiste, Soenens, and Van Petegem, [19] demonstrated that teacher control negatively impacted upon satisfaction of the psychological needs (autonomy, competence, and relatedness with others) and autonomous motivation. In contrast, it positively influenced frustration of psychological needs and controlling forms of motivation. On the other hand, Trigueros et al. [15] have shown that when teachers exert psychological control in PE classes, enjoyment, trust, and motivation of students are negatively impacted. Further, De Meyer [20] confirmed that the controlling role of teachers positively predicted controlled forms of motivation and demotivation, and negatively impacted autonomous motivation.

Given the interest shown in these issues, the present study seeks to analyze the influence of the controlling role of teachers on frustration of the four psychological needs (autonomy, competence, relatedness with others, and novelty), taking the dark side of the SDT. This is crucial given that there is a lack of studies that have analyzed this issue. The line of work opened by González-Cutre et al. [12] and Trigueros et al. [15] will set the basis of the study. In addition, the study wishes to deepen knowledge about the influence of frustration of the four psychological needs on emotional intelligence, as previous research has barely considered the emotions experienced by students during PE classes, and much less recognition of these emotions. It has been concluded that the area of PE specifically contributes to the development of social and emotional intelligence due to the fact that it provides a conducive environment to the transmission of feelings and emotions that humanize personal contact through motor activities [21].

Emotional intelligence (IE) is understood as a skill that facilitates the recognition and regulation of emotions and supports the generation of adaptive behaviors [22]. However, multiple theories have been developed to help better understand the concept of IE, with two in particular standing out: The trait model [23] and the ability model [24]. Both theories have various elements in common, such as the fact that emotions are considered as predictors of positive adaptive behaviors [25]. Nevertheless, differences lie in the fact that the trait theory considers IE as a construct that is linked to the set of stable personality traits, socio-emotional competencies, motivational aspects, and diverse cognitive skills that are essential for overcoming demands and pressures [23]. In exchange, the ability model considers IE as another form of intelligence that is based on the adaptive use of emotions and their application to thinking, and facilitates adaptation of the individual to the environment and problem solving.

According to various studies in the educational context, IE has been positively associated with better psychological wellbeing in students [26], emotional wellbeing [25], academic performance, social relationships [27], self-efficacy and empathy [28]. On the other hand, emotional intelligence has been negatively associated with stress [26], depression [29], and negative emotions [30]. All of these are elements that can lead to the generation of maladaptive behaviors.

Following this thread, the present study seeks to analyze within the context of PE, the extent to which emotional intelligence is related with meta-cognitive strategies. In this sense, meta-cognitive strategies could provide a useful tool to help students assimilate information from the exterior via their own knowledge and skills, or those that they are now able to acquire [31]. To this end, emotional intelligence can exert a significant influence upon meta-cognitive strategies given that recognition and control of one's own emotions largely determines decision making [32].

Bearing these considerations in mind, the present study was designed in which the following hypotheses were proposed (see Figure 1): (1) Teacher control will positively predict the frustration of psychological needs and the frustration of novelty; (2) frustration of the four psychological needs (autonomy, competence, novelty, and relatedness with others) will positively predict emotional intelligence; and (3) emotional intelligence will positively predict meta-cognitive strategies.

2. Method

2.1. Participants

The sample was formed by 1602 secondary school students (820 males and 882 females), with ages reported between 13 and 19 years (M = 15.73; SD = 1.30). All participants came from the province of Almeria. Non probabilistic convenience sampling was employed as a function of the educational centers and students that could be accessed.

2.2. Instruments

Controlling style. The Spanish version developed by Trigueros et al. [33] and adapted from the Controlling Coach Behaviors Scale (CCBS) of Bartholomew, Ntoumanis, and Thogersen-Ntoumani [34] was used. This questionnaire comprised 15 items divided between four factors, which measured control through rewards, negative conditioning, intimidation, and excessive personal control. The questionnaire was responded to via a Likert scale that runs from 1 (totally disagree) to 7 (totally agree).

Frustration of psychological needs: The Frustration of Psychological Needs in PE classes Scale of Trigueros, et al. [13] was used. The scale comprises 17 items divided between autonomy, competence, relatedness with others, and novelty. The questionnaire is headed by the phrase "During PE classes . . . " and is responded to via a Likert scale that runs from 1 (totally disagree) to 7 (totally agree).

Emotional Intelligence. The Spanish version of the Emotional Intelligence in PE Scale of Cecchini et al. [25] was used. This scale was developed from the version of Arruza et al. [35]. The questionnaire comprises 22 items divided between three factors, which measure the capacity to recognize one's own emotions, emotional control and regulation, and emotional empathy. The questionnaire is responded to via a Likert scale that runs from 1 (totally disagree) to 7 (totally agree).

Learning focus. The Motivated Strategies for Learning Questionnaire (MSLQ; [36]) which was validated and adapted into Spanish by Roces, Tourón and González [37] was used with the purpose of measuring strategies of meta-cognition. Only the 12 items that refer to metacognition strategies were used. Students responded using a Likert scale that ranged from 1 (not at all true) to 5 (totally true).

2.3. Procedure

Firstly, permission was requested from the Bioethical Committee for Human Research of the University of Almeria (Ref. UALBIO 2019/014) with the aim of contacting various educational centers in the province of Almeria. After informing the educational centers about the objectives of the study, the parents or legal guardians signed informed consent as the pupils were underage. Scales were administered to participants. This was done under the supervision of the study's principal researcher, who provided instructions and resolved any doubts that arose during questionnaire completion. The time taken to complete the questionnaire was estimated at around 25 min.

2.4. Data Analysis

Initially, descriptive statistical analysis (mean and standard deviation) was conducted through *Pearson* correlation, carrying out correlational analysis between all study variables. Next, internal consistency was examined (Cronbach alpha) with the purpose of testing reliability of the factors integrated within the study. Following this, the hypothesized predictive model was tested via a structural equation model (MEE).

For the MEE, the maximum likelihood estimation model with bootstrapping was conducted using the statistical package AMOS 20. In order to judge the model tested, various fit indices were considered: χ^2 /gl, CFI (Comparative Fit Index), IFI (Incremental Fit Index), RMSEA (Root Mean Square Error of Approximation) alongside its associated confidence interval (IC) al 90%, and SRMR (Standardized Root Mean Square Residual). Values of χ^2/gl lower than 3, values for the incremental indices (CFI, IFI) equal to or greater than 0.95, and RMSEA and SRMR values lower than or very close to 0.06 and 0.08, respectively, were considered to indicate adequate fit of the model to the study data [38]. However, Marsh, Hau, and Wen [39] state that these cut-points must be interpreted with caution as they have been shown to be excessively restrictive and difficult to achieve when complex models are tested.

3. Results

3.1. Descriptive Statistics, Reliability Analysis, and Bivariate Correlations

As shown in Table 1, participating students obtained a mean score for emotional intelligence and meta-cognitive strategies of 4.95 and 3.22, respectively. Analysis of internal consistency revealed

Cronbach alpha values that were greater than 0.80 for each of the variables. Correlation analysis showed that those factors that are linked to the dark side of the SDT were positively correlated amongst themselves, whilst being negatively related to emotional intelligence and meta-cognitive strategies. In contrast, the relationship between emotional intelligence and meta-cognitive strategies produced a negative correlation.

Table 1. Descriptive statistics, internal consistency analysis and bivariate correlations.

Factors	*M*	*DT*	Range	α	1	2	3	4	5	6	7
1. Psychological Control	1.82	1.06	1–7	0.82		0.47 ***	0.48 **	0.50 ***	0.49 ***	−0.52 ***	−0.45 ***
2. Frust. Autonomy	2.12	1.47	1–7	0.83			0.68 ***	0.57 ***	0.65 ***	−0.42 **	−0.36 ***
3. Frust. Competence	2.14	1.32	1–7	0.88				0.70 ***	0.71 **	−0.40 ***	−0.33 ***
4. Frust. Relatedness with others	1.96	1.33	1–7	0.81					0.70 ***	−0.46 **	−0.38 **
5. Frust. Novelty	1.88	1.34	1–7	0.87						−0.47 ***	−0.41 ***
6. Emotional Intelligence	4.95	1.51	1–7	0.92							0.76 ***
7. Meta-Cognitive Strategies	3.22	1.12	1–5	0.83							

*** $p < 0.001$; ** $p < 0.01$. Note: M = Mean; SD = Standard deviation; α = Cronbach alpha; Frust = Frustration.

3.2. Structural Equation Model Analysis

For the hypothesized model of predictive relationships (Figure 1), fit indices were shown to be adequate: χ^2 (551, N = 1602) = 1774.90, $\chi^2/gl = 3.22$, $p < 0.001$, IFI= 0.96, CFI = 0.96, RMSEA = 0.052. (IC 90% = 0.047 − 0.061), SRMR = 0.038. These results were adjusted to established parameters, thus, the proposed model can be accepted as demonstrating adequate fit [39].

Following this, the relationships obtained between the different factors integrated in the model were described (Figure 1):

(1) Teachers' psychological control positively predicted frustration of each one of the psychological needs: Autonomy (β = 0.54, $p < 0.001$), competence (β = 0.63, $p < 0.001$), relatedness with others (β = 0.52, $p < 0.01$) and novelty (β = 0.33, $p < 0.001$).

(2) Frustration of autonomy negatively predicted emotional intelligence (β = −0.41, $p < 0.001$); frustration of competence negatively predicted emotional intelligence (β = −0.52, $p < 0.01$); frustration of novelty negatively predicted emotional intelligence (β = −0.29, $p < 0.001$); and finally, frustration of relatedness with others negatively predicted emotional intelligence (β = −0.43, $p < 0.001$).

(3) Emotional intelligence predicted meta-cognitive strategies (β = 0.60, $p < 0.001$) in a positive way.

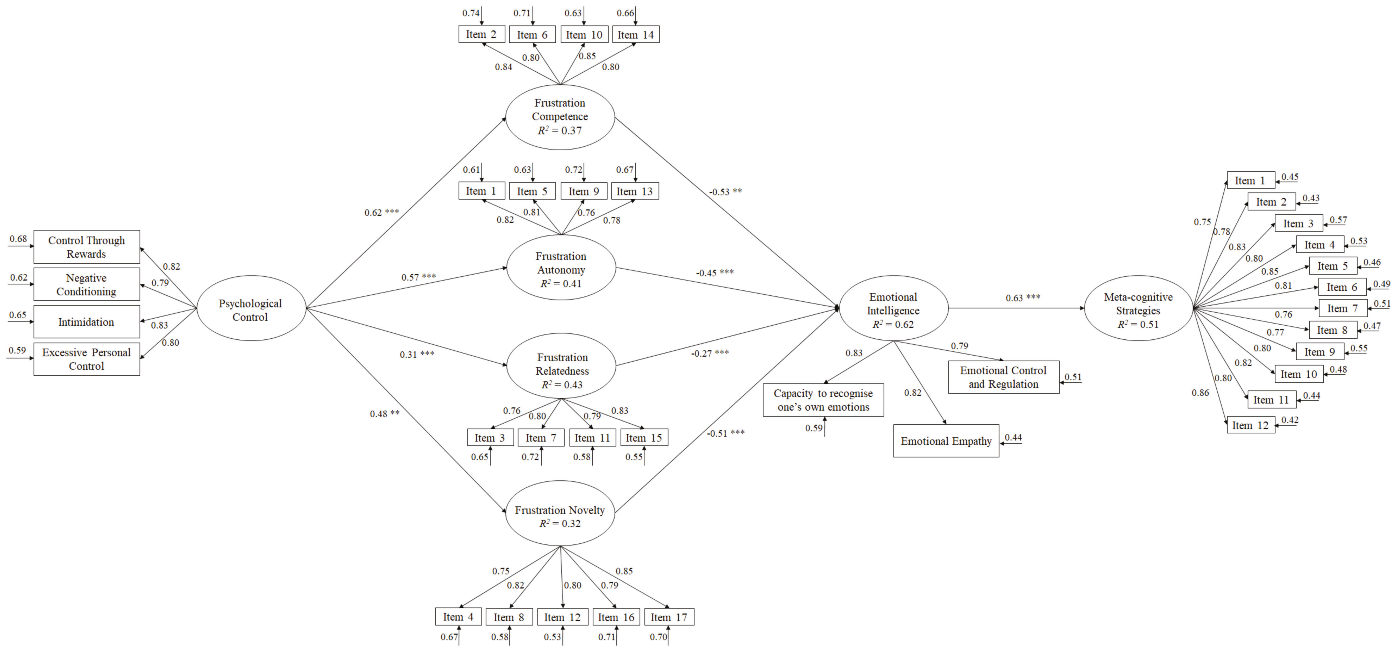

Figure 1. Of structural equations showing the relationships between the different variables. All parameters are standardized and statistically significant. The variances explained are shown above the small arrows. Note: ** $p < 0.001$; ** $p < 0.01$.

4. Discussion

The dark side of the SDT was analyzed (this is to say, psychological controlling and frustration of psychological needs) with regards to its influence on emotional intelligence and meta-cognitive strategy use in secondary school students in the area of PE. Studies up to this moment with PE students have focused only on the light side of the SDT, analyzing the effect of autonomy support, psychological need satisfaction and motivation at a cognitive, physical and social level [4]. In addition, the present study contemplates for the first-time various forms of intelligence in students. This is seen through the fact that being capable of recognizing emotions and knowing how to control them can lead to a series of adaptive behaviors. This includes paying attention to information is one's surroundings [40]. On the other hand, as a novel aspect, the present study centered on an analysis of meta-cognitive strategies. In this sense, the majority of previously conducted studies had observed the motivational processes of students [11] but had failed to indicate how they process information, or their capacity to code and retain it.

Diverse studies in the PE setting, have discussed the positive effect of autonomy support in relation to psychological need satisfaction in PE students and the effect of this, in turn, on motivation towards PE classes [6,41]. However, there are barely any research studies available that have considered the negative aspects also present during PE classes. Such aspects can include the controlling style of the teacher and frustration of psychological needs. Depending on the role of teachers and the perception of students regarding the PE classes in which they participate, such aspects can exert a negative influence over the adoption of adaptive behaviors, both in the present and in the future. In this sense, previous research studies have indicated, on occasion, that low scores for autonomy support and for psychological need satisfaction, are predictors of controlling behavior and frustration, respectively [34]. However, this statement is not totally adequate given that the items of the scale, these being both autonomy support and psychological need satisfaction, only collect information regarding positive experiences. In this way, it is unlikely that negative aspects of these experiences would emerge [42].

Results of the present study showed that perceived control positively predicts frustration of each one of the psychological needs (e.g., autonomy, competence, and relatedness with others), in addition to novelty frustration. These results are comparable to those reported by the few other conducted studies, at both a national and international level, where it has been demonstrated that psychological controlling could be positively related with frustration of psychological needs [43,44]. Thus, these results are along the same lines as those presented by previous studies and fall within the tenants of the SDT. The results highlighted that the relationships between psychological controlling, psychological need frustration and novelty, can explain to a certain extent the likely outcomes for students who perceive a lack of control over their own decisions and teachers who behavior in an autocratic, restrictive, or pressurizing way towards students. It is explained that they will feel overwhelmed, incapable and rejected, due to them feeling that their psychological needs are being frustrated. Further, when teachers work within their comfort zone, attempt to innovate little and offer the same experiences during their classes, students will experience novelty frustration.

It has been shown that each one of the factors relating to psychological need frustration and novelty frustration, negatively predict emotional intelligence. This data can be compared to that of other studies conducted in other fields. In this sense, a study carried out from the light perspective of the SDT showed that psychological need satisfaction acted as a predictor of the emotional wellbeing of students [45]. In addition, Cordeiro, Paixão, Lens, Lacante, and Sheldon [46] indicated that psychological need satisfaction acted as a positive predictor of psychological and emotional wellbeing. In contrast, frustration of psychological needs acted as a negative predictor of these aspects. Further, results of the present study show agreement with the tenants of the SDT [6], given that psychological need frustration can trigger a series of maladaptive consequences such as disinhibition and/or engagement in behaviors that go against personal wellbeing. This is supported by outcomes of a study carried out by Balluerka, Gorostiaga, Alonso-Arbiol, and Aritzeta [47], which showed high levels of emotional intelligence in students to act as predictors of psychological and emotional wellbeing.

As a consequence, it is necessary that PE teachers work with students throughout the full duration of the course to develop their emotions and control, with the aim of becoming conscious of these emotions and thus, being able to work towards a greater level of wellbeing [19]. Further, it is also fundamental that PE classes are motivational and interesting so that students can take away positive lived experiences that will favor their learning.

Finally, the present results showed that emotional intelligence acts as a positive predictor of meta-cognitive strategies. The conclusions are similar to those drawn by Hasanzadeh and Shahmohamadi [48] with university students enrolled on various degree programs. These authors also showed a positive relationship between emotional intelligence and the use of meta-cognitive strategies. In this sense, Villavicencio and Bernardo [49] state that emotions act as a link between sensory information and thought. In this way, when experiences are interpreted in a positive way we feel motivated to act and to achieve objectives. In contrast, when experiences are interpreted in a negative way we do not act. This creates a maladaptive and counter-productive behavioral pattern, which impedes learning and stunts emotional/mental growth.

Finally, it is highlighted that the present research shows support for the tenants of the SDT, taking the dark side, introducing new variables and demonstrating their applicability in Spanish culture. The model seems to show good robustness and capacity for generalization towards different cultures or ages. It helps us to better understand the role played by the teacher in the cognitive and emotional processes of students, in addition to lending a deeper understanding of learning strategies. However, as one of the limitations of the present study, it must be indicated that it deals with a correlational study design which does not permit causal relationships to be identified. Further, the results obtained can be interpreted in a number of ways depending on the understanding of a given individual. To this end, the model sought to present different probabilities with the purpose of explaining existing relationships between study variables. In this way, future research studies should conduct a deeper analysis of the results achieved through intervention studies in order to better clarify the relationship between the different variables. In addition, future studies should analyze the differences in relation to the emotional state and motivation towards the Physical Education classes of the adolescents according to their country of residence. Finally, it would be interesting to understand the influence of motivation and the concrete emotional state of each individual according to age, given the variability young people suffer as they grow and start to become more autonomous in their decision making, in addition, the possibility of analyzing the pressure exerted by the social context on young people's decision-making as they grow should not be overlooked.

Author Contributions: Conceptualization, R.T.; Formal analysis, J.M.A.-P.; Investigation, R.T. and P.R.; Project administration, P.R.; Supervision, R.L.-L.; Validation, R.L.-L.; Visualization, R.T.; Writing— riginal draft, R.T.; Writing— review & editing, J.M.A.-P.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Effects of Motivation, Basic Psychological Needs, and Teaching Competence on Disruptive Behaviours in Secondary School Physical Education Students

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Received: 17 November 2019; Accepted: 28 November 2019; Published: 1 December 2019

Abstract: Currently, disruptive and aggressive behaviours of a physical and verbal nature are a reality among adolescent students and a concern in the educational context. Therefore, the main objective of this research was to analyse the effects of perceived teaching competence, motivation and basic psychological needs on disruptive behaviours in secondary school PE students. The sample was composed of 758 adolescent students from seven public secondary schools. The following instruments adapted to physical education were used: The Disruptive Behaviours Questionnaire, The Evaluation of Teaching Competencies Scale, The Sport Motivation Scale, and The Basic Psychological Needs Scale. Multilevel regression models with the MIXED procedure were performed for data analysis. The results show that misbehaviour is more likely among male students and that disruptive behaviours decrease when a teacher is perceived as competent. Students with greater self-determined motivation are more likely to exhibit fewer behaviours related to low engagement and irresponsibility while amotivation increases the different disruptive behaviours in the classroom. In conclusion, it is proposed that educators work in line with the students' needs by responding to their interests and that this will increase self-determined motivation.

Keywords: misbehaviours; adolescent; teaching; secondary school; multilevel regression models

1. Introduction

Nowadays, disruptive behaviours, and even aggressive physical and verbal behaviours are a reality among adolescent students in the educational context [1–3]. These misbehaviours are related to school failure [3] and are considered as predictors of future violent behaviours both in the school context [4,5] and in the formation of dangerous social environments [6]. The importance of this problem in the classroom has meant that more and more research has been directed towards the indiscipline and disruptive behaviours of primary and secondary school students as an indicator of teaching success or failure [5,7–9]. Moreover, these types of behaviours cause stress and work loss amongst teachers [10,11]

According to the self-determination theory (SDT) [6], student behaviours during a class may vary depending on a number of factors, such as motivation or the satisfaction of basic psychological needs (BPN). It considers that the educational context strongly influences student motivation and the control of disruptive behaviours, and is the reason for the proliferation of studies in this regard [12,13]. The explanation for certain personal decisions made by schoolchildren may be based on the relationship between motivation and social, family or personal factors [14]. However, it is also important to understand the students' perception of the teacher's competence if one wants to explain "why" there are bad behaviours in the classroom, and to try to reduce them or make them disappear. As Duchesne and Larose [15] state, if students perceive appropriate academic competencies during the learning process, their motivation increases and this prevents potentially disruptive behaviours. Our study addresses the issue in the context of physical education (PE). This subject stands out as promoting a climate of fun, motivation and stress avoidance amongst students, fostering a positive relationship between student satisfaction, the PE curriculum, and the school system itself [8,16–18].

SDT is one of the most important theories studied in relation to educational motivation, and is widely considered in the context of PE [6]. One must bear in mind that the motivational profile of adolescents during sports practice can help to understand their behaviour patterns [19]. It is important to note that human motivation and the functioning of personality are related within a given social context [6] and that there are three established levels: The highest level being self-determined motivation or intrinsic motivation, the intermediate level being extrinsic motivation, and the lowest level of amotivation. With regard to the first, this is understood as the pleasure of participating in an activity by the mere fact of enjoying it, being interested in it, or the personal satisfaction of carrying it out [20]. Intrinsic motivation in PE students produces a greater interest to participate both during the sessions and in their free time [21,22]. Extrinsic motivation, on the other hand, is the activity of a person aimed at meeting an external demand or to get a reward [6]. Finally, amotivation signifies a lack of motivation in practicing an activity, associated with the absence of intent [23], feeling incompetent when performing an activity [24], and the rejection of unexpected results [14].

Continuing with the SDT [6] to explain student behaviour in terms of their BPNs, the theory indicates that these needs may be primarily those of autonomy, competence, and relating to others—all necessary for psychological health. These same authors emphasize that each of the needs indicated plays a prominent role in the optimal development and experiencing of well-being in daily life. The need for autonomy is understood as the effort that people make to determine their own behaviour and the origin of their own actions; the need for capability is understood as controlling the outcome and the eagerness to experience effectiveness; and the need for relating to others alludes to concern for others, making others feel that they have an authentic relationship with oneself so that one might feel accepted and able to fraternize with others [25,26]. The satisfaction of BPN is associated with positive consequences, such as an improvement in autonomous motivation [27]. However, BPNs can also be frustrated and unsatisfied due to restrictions imposed by people in the surrounding environment [28], and in education this is manifested through disruptive behaviours or misbehavior [15,29]. The satisfaction of these three BPNs enhances learning in the PE class when adequate motivation is given to students, fostering greater academic commitment during the learning process [28,30].

At the same time, the figure of the teacher is key in the teaching process and the students' perception of their teacher's competence can be important in explaining bad behaviours in the classroom. Therefore, addressing the perception that students have of teacher competence together with the motivation and satisfaction of their BPNs in explaining disruptive behaviours in the classroom is the main novelty and contribution of this research to the scientific literature.

It should be remembered that in secondary education, the teacher is not evaluated by her/his own students, which does not help to ensure the internal quality of the teaching-learning process—the same goes for PE. It is therefore important that the methodology and approach used by the teacher is increasingly studied, considering, among other things, different competencies [31,32]. As some authors point out (e.g., [33]), the ways in which the PE teaching staff handles their classes regarding time, or the teaching environment, are essential factors in dealing with disruptive behaviours. Some uncertainty still exists when it comes to knowing how teachers achieve the skills necessary to carry out their teaching work, about how they confront the challenges of today's society with their students, and how they assess the students' needs [10]. As Christie, Quiñones, and Fierro [34] noted, a considerable number of teachers have doubts when having to make assessments although they would like to gain sufficient knowledge and competence to do so well. All of these aspects, such as the lack of competencies and teacher's experience of dealing with difficult situations, are relevant in highlighting the importance of the teacher's persona when it comes to handling disruptive behaviours [33].

Taking into account all of the above, the main objective of this study is to analyse the effects of perceived teaching competence, motivation, and basic psychological needs on disruptive behaviours in secondary school students in the PE class.

2. Materials and Methods

2.1. Participants

The design of this cross-sectional study is observational and descriptive. A non-probabilistic and convenience sample selection process was employed, based on the students that we were able to assess. This research included secondary school PE students—a total of 758 students (45.8% male) participated from seven secondary schools in the Murcia region. The age range was between 13 and 18 years old (M = 15.22, SD = 1.27; M_{boys} = 15.20, SD_{boys} = 1.29; M_{girls} = 15.18, SD_{girls} = 1.26).

2.2. Measurements

Disruptive Behaviours in Physical Education. The Disruptive Behaviour in Physical Education Questionnaire (CCDEF) [8] was used, the Spanish version of the original *Physical Education Classroom Instrument* (PECI) [33]. This version consists of 17 items that measure disruptive behaviours in PE students over five subscales: *Aggressive* (AGR) (2 items), *low engagement or irresponsibility* (LEI) (4 items), *fails to follow directions* (FFD) (4 items), *distracts or disturbs others* (DDO) (4 items), and *low self-management* (PSM) (3 items). A five-point Likert scale ranging from 1 (*never*) to 5 (*always*) was used for the responses. The internal consistency indexes were: AGR, Cronbach's alpha (α) = 0.58, composite reliability = 0.81, average variance extracted (AVE) = 0.54; LEI, α = 0.73, composite reliability = 0.84, AVE = 0.74; FFD, α = 0.77, composite reliability = 0.94, AVE = 0.65; DDO, α = 0.81, composite reliability = 0.92, AVE = 0.80; PSM, α = 0.84, composite reliability = 0.96, AVE = 0.92. Given the low Cronbach's alpha index and that the AGR subscale only consists of two items, this factor was ignored in the analyses we performed. The goodness-of-fit indices for the CCDEF scale using the confirmatory factorial analysis (CFA) were chi-squared (χ^2)/degrees of freedom (df) = 3.61; incremental fit index (IFI) = 0.96; Tucker-Lewis index (TLI) = 0.95; comparative fit index (CFI) = 0.96; root mean square error of approximation (RMSEA) = 0.06; and standardized root mean square residual (SRMR) = 0.06.

Teaching competence. The Spanish version of the *Evaluation of Teaching Competencies Scale adapted to Physical Education* (ETCS-PE) [31] was used, adapted from the original *Evaluation of Teaching Competencies Scale* [35]. This consists of eight items that measure the students' perception of teacher effectiveness. A seven-point Likert scale ranging from low (1, 2), medium (3, 4, 5), and high (6, 7) was used for the responses. The internal consistency indices were: α = 0.86, composite reliability = 0.86, AVE = 0.59. The goodness-of-fit indexes of the scale using the CFA were: χ^2/df = 1.80; IFI = 0.99; TLI = 0.99; CFI = 0.99; RMSEA = 0.03; SRMR = 0.02.

Sport Motivation Scale (SMS). The Spanish version of the original *Sport Motivation Scale* [36], adapted to PE [37] was used. This consists of 28 items that measure the different types of motivation established by the SDT [23], which suggests the multidimensional explanation of motivation: *Amotivation* (AMO), *extrinsic motivation* (EM) (12 items), and *intrinsic motivation* (IM) (12 items). Responses were collected on a Likert scale ranging from 1 (*totally disagree*) to 7 (*fully agree*). The internal consistency found in this study was: IM, α = 0.91, composite reliability = 0.99, AVE = 0.92; EM, α = 0.91; composite reliability = 0.99, AVE = 0.88; AMO, α = 0.75, composite reliability = 0.85 and AVE = 0.58. The goodness-of-fit indexes for the scale using AFC were: χ^2/df = 3.02; IFI = 0.96; TLI = 0.97; CFI = 0.98; RMSEA = 0.05; SRMR = 0.04.

Basic Psychological Needs. The Spanish version of the *Basic Psychological Needs Measurement Scale* [25] was used, adapted from the original *Basic Psychological Needs in Exercise Scale (BPNES)* [38]. This consists of 12 items grouped into three dimensions of four items each: *Autonomy* (AUT), *competence*

(COM), and *relatedness* (REL). A Likert scale ranging from 1 (*totally disagree*) to 5 (*totally agree*) was used for the responses. The internal consistency found in this study was: AUT, $\alpha = 0.82$, composite reliability = 0.88, AVE = 0.65; COM, $\alpha = 0.78$; composite reliability = 0.88, AVE = 0.64; REL, $\alpha = 0.75$, composite reliability = 0.90, AVE = 0.69. The goodness-of-fit indexes for the scale using AFC were: $\chi^2/df = 3.88$; IFI = 0.96; TLI = 0.95; CFI = 0.95; RMSEA = 0.05; SRMR = 0.06.

2.3. Procedure

Permission to carry out the work was obtained from the competent bodies, whether at the secondary schools or at the university. The parents and the adolescents were informed of the protocol and the study's subject matter. The informed consent of both was an indispensable requirement to participate in the research. The tools measuring the different variables were administered in the classroom by the researchers themselves, without the teacher present. All participants were informed of the study objective, the voluntary and confidential nature of the responses and the data management, as well as their rights as participants thereof, based on the document approved by the Ethics Committee of the University of Murcia (REF-45-20012016).

2.4. Statistical Analyses

The descriptive statistics of the items, the correlations, and the internal consistency of each subscale were calculated, as well as the asymmetry and kurtosis, the statistics of which achieved values of between −0.78 and 1.67. Since the sample was made up of different subgroups (e.g., school and course), which might constitute a breach of the independence of observations assumption, it was considered relevant to use regression and multilevel modelling analysis (MLM) [39], taking into account the variables of the participants' individual characteristics (level 1) and the context variables (level 2) [40]. The grouping or level of the students' school and course was considered as a random effect. Different multilevel regression models were tested according to the different combinations of school and course levels, including a zero model in each of the CCDEF subscales. To check the effects of teaching competence, motivation, and basic psychological needs on each of the factors of disruptive behaviours, which acted as dependent variables, different models were tested in which the sex and age variables were also taken into account.

The multilevel regression analyses were performed with the SPSS 22.0 MIXED (IBM, Chicago, IL, USA) procedure using the restricted maximum likelihood estimation method. The –2 log-likelihood (–2LL) and the Akaike information criterion (AIC) [41,42] statistical equations were used as goodness-of-fit measures between models. In addition, to indicate the absence of lost values and the assumption of normality of the residuals for all the models, these were checked in all cases. The reduction or exclusion of possible interactions between the model-independent variables was carried out using the goodness-of-fit measures mentioned above, along with checking the hypothesis contrasts associated with the intersection parameters.

3. Results

3.1. Descriptive and Correlation Analysis

As shown in Table 1, the average scores of the different scales achieved moderate values, although these were quite low among the factors for disruptive behaviours. In terms of motivation, the *intrinsic motivation* score was higher and the *amotivation* score was lower. Among the basic psychological needs, *competence* presented higher mean values while the *autonomy* values were lower. Regarding disruptive behaviours, *low engagement or irresponsibility* presented the highest means while *poor self-management* was the lowest.

Table 1. Descriptive statistical and correlations.

Subscales	1	2	3	4	5	6	7	8	9	10	11	12
1. Age	-	0.05	0.02	0.01	−0.06	−0.02	−0.00	−0.01	0.02	0.04	0.00	0.05
2. ETCS-EF		-	0.43 **	0.39 **	0.06	0.41 **	0.25 **	0.19 **	−0.21 **	−0.15 **	−0.12 **	−0.10 **
3. IM			-	0.82 **	0.17 **	0.61 **	0.56 **	0.45 **	−0.25 **	−0.19 **	−0.10 **	−0.08 *
4. EM				-	0.29 **	0.58**	0.53 **	0.43 **	−0.18 **	−0.19 **	−0.05	−0.04
5. AMO					-	0.15**	−0.03	−0.03	0.18 **	0.26 **	0.24 **	0.20 **
6. AUT						-	0.67 **	0.50 **	−0.14 **	−0.07	−0.01	0.04
7. COM							-	0.57 **	−0.20 **	−0.16 **	−0.08 *	−0.04
8. REL								-	−0.15 **	−0.19 **	−0.14 **	−0.09 *
9. LEI									-	0.70 **	0.64 **	0.59 **
10. FFD										-	0.71 **	0.66 **
11. DDO											-	0.79 **
12. PSM												-
M	15.20	5.36	4.94	4.85	3.72	3.18	3.56	3.83	2.00	1.65	1.49	1.42
SD	1.36	1.16	1.36	1.25	1.57	0.94	0.89	0.90	0.90	0.84	0.79	0.83

Note. *M* = mean; *SD* = standard deviation; ETCS-PE = teaching competence; IM = intrinsic motivation; EM = extrinsic motivation; AMO = amotivation; AUT = autonomy; COM = competence; REL = relatedness; LEI = low engagement or irresponsibility; FFD = fails to follow directions; DDO = distracts or disturbs others; PSM = poor self-management; ** $p < 0.01$; * $p < 0.05$.

In Table 1, one can observe how age did not correspond significantly, from the statistical standpoint, to any subscale. The positive and statistically significant correlations between *teaching competence* and *intrinsic motivation*, *extrinsic motivation* and *autonomy* stand out, as do those between *intrinsic motivation* and *extrinsic motivation*, and between the four CCDEF subscales. In contrast, disruptive behaviours presented negative correlations with the other dimensions, except for *motivation*, highlighting the statistically significant relationships with *teaching competence*, *intrinsic motivation*, and *relatedness*. Conversely, for *amotivation*, the correlations of the CCDEF subscales (LEI, FFD, DDO, PSM) were positive and statistically significant.

3.2. Multilevel Regression Analysis

A multilevel regression model without predictor variables (the null model, M0) was tested. M0 served to evaluate the predictive gain of models in which the predictor variables were included, both the constant effect and the random effects of school and course. Based on the goodness-of-fit values of the evaluated models, we found that the model including the school and the constant (M1) had the greatest effect on the independence of the observations: M0, −2LL = 1990.22; M1, −2LL = 1964.35 (χ^2 = 25.87; df = 1; $p < 0.0001$). An intraclass correlation coefficient (ICC) was calculated: ICC = 0.12 in LEI; ICC = 0.08 in FFD; ICC = 0.17 in DDO; and ICC = 0.07 in PSM. This indicates that between 7% and 17% of the total variability, depending on the dependent variable, is attributable to the difference between the mean of the different schools.

Based on the M1 results, different models were tested considering the grouping or level of the school. In these models, the dependent variable (the four CCDEF factors) was changed and, in each of them, the independent level 1 variables (model 2, M2) were introduced into the regression equation, namely sex, age, ETCS-PE, IM, EM, AMO, AUT, COM, and REL.

Table 2 shows the results of the models in which the dependent variable was *low engagement or irresponsibility*. In M2, one can observe that the effects of age were not statistically significant, nor were the EE, AUT, and REL effects. In contrast, the effects of sex, ETCS-PE, IM, AMO, and COM were statistically significant. Next, model 3 (M3) was estimated, from which the variables whose effects were not statistically significant on *low engagement or irresponsibility* were removed. The goodness-of-fit indexes indicated a better fit for M3 than for M2 (χ^2 = 12.27; df = 5; $p < 0.05$). In M3, the effect of the student's own competence (COM) was not statistically significant so it was eliminated to estimate model 4 (M4) in which the variables that did have predictive and statistically significant effects were included. M4 did not represent a statistically significant improvement over M3 (χ^2 = 1.89; df = 4; $p > 0.05$), so M3 was adapted as the most suitable model. Thus, it was proven that, for the boys, it is more likely that irresponsibility will occur as disruptive behaviour. In addition, as greater teacher competence is perceived, the student has greater intrinsic motivation, which means irresponsibility is more likely to decrease. However, if amotivation increases, irresponsibility and poor self-management is more likely to increase.

Table 2. Regression and multilevel modelling analysis: Estimations and adjustments. Dependent variable: Low engagement or irresponsibility.

	Models								
	M2			M3			M4		
	Estimation (Error)	**t**	**(sig.)**	**Estimation (Error)**	**t**	**(sig.)**	**Estimation (Error)**	**t**	**(sig.)**
Variables									
Sex	0.26 (0.06)	6.76	0.000	0.27 (0.06)	4.40	0.000	0.25 (0.06)	4.14	0.000
Age	0.03 (0.02)	1.35	0.178						
ETCS-PE	−0.09 (0.03)	−3.15	0.002	−0.08 (0.03)	−2.78	0.006	−0.08 (0.03)	−2.84	0.005
IM	−0.17 (0.05)	−3.56	0.000	−0.14 (0.03)	−4.75	0.000	−0.17 (0.03)	−6.70	0.000
EM	0.02 (0.05)	0.47	0.642						
AMO	0.11 (0.02)	5.31	0.000	0.12 (0.02)	5.98	0.000	0.13 (0.02)	6.39	0.000
AUT	0.08 (0.05)	1.62	0.105						
COM	−0.12 (0.05)	−2.37	0.018	−0.08 (0.04)	−1.86	0.063			
REL	0.00 (0.04)	0.10	0.920						
Adjustment Statistics									
Deviance (−2LL)		1902.95			1890.68			1889.65	
AIC		1904.95			1892.68			1891.65	

Note. Sex: 0 = female; 1 = male; M2 = model 2; M3 = model 3; M4 = model 4; ETCS-PE = teaching competence; IM = intrinsic motivation; EM = extrinsic motivation; AMO = amotivation; AUT = autonomy; COM = competence; REL = relatedness; −2LL = −2log-likelihood; AIC = Aikake information criterion.

The results of the models in which the dependent variable was *Fails to follow directions* are shown in Table 3. In M5, the effects of age, MI, ME, and COM were evaluated and they did not prove to be statistically significant. Therefore, these variables were removed from M6, which included sex, ETCS-EF, AMO, AUT, and REL. The goodness-of-fit indexes indicated a worse fit for M6 than for M5 (χ^2 = 1.62; df = 5; p > 0.05). In this way, the effect of sex on *disobeying the rules* was also determined, and it was significantly more likely to occur amongst boys than amongst girls. Furthermore, disobedient behaviour is more likely to decrease as more teacher competence is perceived and social relations improve with the others. In contrast, increased amotivation would mean greater disobedience is more likely amongst the boys, as has been indicated. Feeling more autonomous can also lead to increased disobedience, so every effort must be made to positively channel that autonomy.

Table 3. Regression and multilevel modelling analysis: Estimations and adjustments. Dependent variable: Fails to follow directions.

	Models					
	M5			M6		
	Estimation (Error)	**t**	**(sig.)**	**Estimation (Error)**	**t**	**(sig.)**
Variables						
Sex	0.25 (0.06)	4.48	0.000	0.23 (0.06)	4.00	0.000
Age	0.04 (0.02)	1.95	0.052			
ETCS-PE	−0.07 (0.03)	−2.46	0.014	−0.10 (0.03)	−3.60	0.000
IM	−0.08 (0.04)	−1.82	0.069			
EM	−0.06 (0.05)	−1.25	0.214			
AMO	0.15 (0.02)	7.51	0.000	0.13 (0.02)	7.13	0.000
AUT	0.12 (0.05)	2.67	0.008	0.02 (0.04)	0.41	0.681
COM	−0.06 (0.05)	−1.29	0.197			
REL	−0.10 (0.04)	−2.48	0.013	−0.16 (0.04)	−4.38	0.000
Adjustment Statistics						
Deviance (−2LL)		1781.77			1780.15	
AIC		1783.77			1782.15	

Note. Sex: 0 = female; 1 = male; M5 = model 5; M6 = model 6; ETCS-PE = teaching competence; IM = intrinsic motivation; EM = extrinsic motivation; AMO = amotivation; AUT = autonomy; COM = competence; REL = relatedness; −2LL = −2log-likelihood; AIC = Aikake information criterion.

The same was process was carried out for the *Distracts or disturbs others* variable and the results of the models are shown in Table 4. After the variables were removed whose effects were not statistically significant on M7 (age, MI, ME, and COM), M8 did not show a significant improvement (χ^2 = 7.73; df = 5; $p > 0.05$), so the M7 results were accepted. The sex variable continued to present statistically significant values with boys more likely to be *disruptive in the class environment*; however, in this case too, greater teacher competence and improved social relations with classmates would be predictors of less disruption in the classroom. As with disobeying the rules, amotivation and feeling more autonomous can lead to an increase in disruptive behaviour in the classroom.

Table 4. Regression and multilevel modelling analysis: Estimations and adjustments. Dependent variable: Distracts or disturbs others.

	Models					
	M7			M8		
	Estimation (Error)	**t**	**(sig.)**	**Estimation (Error)**	**t**	**(sig.)**
Variables						
Sex	0.25 (0.06)	4.39	0.000	0.24 (0.06)	4.31	0.000
Age	0.01 (0.02)	0.64	0.522			
ETCS-PE	−0.06 (0.03)	−2.28	0.023	−0.08 (0.03)	−3.06	0.002
IM	−0.07 (0.04)	−1.52	0.130			
EM	−0.01 (0.05)	−0.24	0.810			
AMO	0.12 (0.02)	6.17	0.000	0.10 (0.02)	6.23	0.000
AUT	0.10 (0.04)	2.37	0.018	0.05 (0.04)	1.41	0.159
COM	−0.02 (0.05)	−0.39	0.695			
REL	−0.10 (0.04)	−2.73	0.006	−0.13 (0.03)	−3.87	0.000
Adjustment Statistics						
Deviance (–2LL)		1736.56			1728.83	
AIC		1738.56			1730.83	

Note. Sex: 0 = female; 1 = male; M7 = model 7; M8 = model 8; ETCS-PE = teaching competence; IM = intrinsic motivation; EM = extrinsic motivation; AMO = amotivation; AUT = autonomy; COM = competence; REL = relatedness; –2LL = –2log-likelihood; AIC = Aikake information criterion.

The results for low personal self-control are shown in Table 5. M9 was estimated and the variables whose effects were not statistically significant (age, intrinsic motivation, extrinsic motivation, competence, and relatedness) were removed to estimate M10. However, this model did not present a better fit than the previous model (χ^2 = 0.37; df = 4; $p > 0.05$) so the M9 results were accepted. The predictive values are even higher in the case of low personal self-control amongst males (0.35) and these are accentuated if there is amotivation and a feeling of more autonomy. Only increased teaching competence is shown as a statistically significant predictor for greater personal self-control on the part of students.

Table 5. Regression and multilevel modelling analysis: Estimations and adjustments. Dependent variable: Poor self-management.

	Models					
	M9			M10		
	Estimation (Error)	t	(sig.)	Estimation (Error)	t	(sig.)
Variables						
Sex	0.35 (0.06)	5.95	0.000	0.34 (0.06)	5.76	0.000
Age	0.04 (0.02)	−2.05	0.073			
ETCS-EF	−0.06 (0.03)	−2.05	0.041	−0.08 (0.03)	−2.83	0.005
IM	−0.07 (0.04)	−1.45	0.146			
EM	−0.04 (0.05)	−0.73	0.468			
AMO	0.10 (0.02)	4.98	0.000	0.09 (0.02)	5.08	0.000
AUT	0.16 (0.05)	3.52	0.000	0.03 (0.03)	0.90	0.367
COM	−0.03 (0.05)	−0.66	0.509			
REL	−0.07 (0.04)	−1.88	0.060			
Adjustment Statistics						
Deviance (–2LL)		1811.04			1810.67	
AIC		1813.04			1812.67	

Note. Sex: 0 = female; 1 = male; M9 = model 9; M10 = model 10; ETCS-PE = teaching competence; IM = intrinsic motivation; EM = extrinsic motivation; AMO = amotivation; AUT = autonomy; COM = competence; REL = relatedness; –2LL = –2log-likelihood; AIC = Aikake information criterion.

4. Discussion

The objective of this work has been to analyse the effects of teaching competence, motivation, and basic psychological needs on the disruptive behaviours of secondary school PE students. Accordingly, we have tried to provide answers to some of the main problems that exist today in classrooms such as behavioural and discipline issues [43], which are common across the different curriculum subjects [44,45]. The present study shows that the various disruptive behaviours are more likely to occur in males. In addition, it is interesting to note that when a teacher is more competent, there are less likely to be behaviour problems amongst students. Regarding motivation, it has been found that, among students with more self-determined motivation, fewer low engagement and irresponsibility behaviours will occur whereas amotivation will increase the various disruptive behaviours in the classroom. On the other hand, it should be pointed out that, amongst the most autonomous students, disciplinary problems are more likely. Therefore, we will now analyse what characteristics should accompany student autonomy during the learning process.

For the students in the present study, the boys were always the ones presenting the greatest disruptive behaviours in the PE class. The results are in line with previous studies where boys showed behaviours more associated with irresponsibility and low commitment in the PE class than girls did [46,47]. Conflict situations in class are often associated with boys because of the importance they place on peer differences, competitiveness, continually striving to win or discrimination of a motor skill [48]. The authoritarian nature that boys can sometimes exhibit, coming from the desire to exaggerate their masculinity in PE classes [49], can lead to disobeying the rules laid down by the teachers. All this contrasts with the role of girls and their behaviour in PE classes, where they show more passive behaviours and a respect for or commitment to the class group and to the teachers [21,50].

On the other hand, PE classes at any educational level are often related to dominant situations and male hegemony, which increases gender disparity [51,52]; this can lead to situations of inequality or taunts amongst students due to low personal self-control. This study illustrates precisely that boys have less personal self-control than girls, coinciding with a previous study of Spanish teenagers where male self-control was difficult to achieve and therefore led to a disruptive environment in the class [46]. Exploratory studies trying to understand power and gender, especially in boys, explain the importance they attach to appearance and how to act in front of others [49,53]. Therefore, this could explain the relationship between the male gender and a disruptive class atmosphere that we observed in our study.

The various disruptive behaviours are present on a daily basis in schools and are of great concern to the different educational agents, such as teachers [3,43]. This study highlights the importance of students perceiving their teachers as competent and prepared to deal with everyday life, as this implies that there is less likelihood of behavioural problems related to classroom instruction; the same conclusion has been reached in various studies [54]. These behaviours affect order and disrupt both the functioning and the environment within the class, which has consequences on the students themselves and on the learning context [3], some of which have been studied in this research—low engagement or irresponsibility, failing to follow directions, distracts, or disturbs others and poor self-management. Although these behaviours are highlighted from the teacher's perspective in current studies [3,55], this paper also highlights the importance of the teacher's own competence in terms of good communication, work awareness, creativity, feed-back, individual consideration, professionalism, problem solving, and social awareness. These aspects have already been the focus of various works [16,35] in linking improved student self-control with the students' perception of adequate teaching competence. This study contributes to the scientific field by stressing the importance of the figure of the competent teacher in preventing or controlling bad behaviour in the classroom. Therefore, this should influence all aspects of teacher training, including the initial training, to ensure that they become as professionally competent as possible.

The results obtained in this study show how low commitment and irresponsibility on the part of the students relates to the lack of teaching competence on the part of PE teachers. It is therefore necessary for PE teachers to offer their students varied and motivating tasks and activities which add quality to the learning and encourage their interest [21,46]. Moreover, students would show openly their motivation and would increase their personal abilities with respect to contents of PE lessons and therefore, there will be an decrease of disruptive behaviours [3].The PE curriculum is one of the most effective of all the school curricula at promoting greater student concentration and commitment but only provided that the appropriate methodological strategies are used by the teachers [56].

With regard to behaviours centered on disobeying the rules, discipline problems in the educational field are common in all areas and subjects that make up the school curriculum [45]. This has serious implications for the teaching-learning process because, among other reasons, they limit the time dedicated to learning [7]. Consequently, PE teachers must create an appropriate classroom environment by fluidly communicating with their students and being as effective as possible when faced with any problematic situation that arises [35,57] using verbal and highly rational strategies, as recommended by some authors [4].

Many teachers and students are concerned about the disorder and the risk of a poor environment in classrooms and schools. The entire educational community is alerted to the high incidence of behavioural problems occurring in schools—drug use, cheating, insubordination, absenteeism, intimidation, etc.—all of which have serious repercussions on the educational community. Behavioural problems in the classroom have long been one of the most discussed and analysed topics in the educational field [58–61].

The degree to which students can disrupt an adequate classroom environment is related to their positive perception of teacher competence, as can be seen in the present study. Traditional and inflexible methodologies on the part of the teacher, justifying higher motor performance and filling the time with physical work, are a cause of dissatisfaction and disruption of the PE class environment [62,63]. An understanding and empathetic attitude by teachers, promoting the inclusion of all students in the PE class through the sharing of responsibilities and continuous dialogue are key to better bonding among the students in the class and between the class and the teachers themselves [63–65].

Likewise, greater personal self-control on the part of the students is related to higher levels of teaching competence. Various symptoms related to the students' lack of control are linked to dissatisfaction with the school, which can even lead to them dropping out of school [66]. Our results are in line with those obtained in a study measuring disruptive behaviours in Spanish adolescent students aged 12–18 in the PE area [8], which concluded that teachers' skills when managing different behaviours and pre-planning are fundamental elements in strengthening the students' personal self-control and controlling disruptive behaviours.

The importance of motivation in the PE class determines the students' satisfaction with this subject [16]. In our study, greater intrinsic motivation on the part of the students was accompanied by less irresponsible behaviours. Several studies have provided similar results to ours with respect to intrinsic motivation [8,36,67,68], favouring in turn a focus and concentration in the PE class and fewer disruptive behaviours [69]. In addition, if one works to promote student responsibility and empowerment through greater autonomy and trust on the part of teachers, serious misbehaviours could decrease considerably, fostering an optimal classroom and learning environment [21,68,70].

On the other hand, amotivation or lack of motivation in the students is an essential criterion when it comes to understanding the level of satisfaction felt by the PE students [71]. If amotivation is high, there tends to be a decrease in engagement and an increase in irresponsible behaviours in the PE class, where no minimal effort exists to commit to the tasks proposed by the teachers [6,71]. A lack of competence when performing physical activities, or not valuing the activities proposed in the PE class are other examples of amotivation [6]. If amotivation can be controlled or minimized by the PE teachers and, at the same time, intrinsic motivation is properly fostered, student commitment can lead to the desired learning of the contents proposed in the class [72,73]. In our study, disobeying the rules, especially for boys, is related to amotivation, explained by the frustration and fear that they may experience when performing a physical test [74,75] or by their rejection of the PE teachers for various reasons [74], many of which we have already commented on. To all that is cited above, one should add that the lack of information when performing physical activities or overcoming a physical test in the PE class can involve amotivation by the students and a respective disobeying of the rules. Therefore, it is necessary to inform the students about the class objectives and to describe the necessary criteria for carrying out any physical activity [16,71].

The basic needs of the students should be met as the PE class develops. Otherwise, students may see no reason to follow the normal development of the class and begin to disrupt the classroom environment [76]. If continued student participation and perseverance in the work are satisfactorily reciprocated by the PE teacher, an optimal response is established which contributes to increased student motivation [77]. Sometimes, the problem is simply that we do not pick up on the signs that our students give off during the course of the PE classes. Therefore, it is necessary to understand the students' perspectives regarding the PE class and towards the teachers themselves in order to interpret the low level of control they feel, and the way they act towards their classmates and the teacher [33].

It is also necessary to adequately manage the autonomy of students or intrinsic motivation in the PE class given that, in this study, it is related to most of the disruptive behaviours. Intrinsic motivation presents in students who act only according to their own interests and values, who feel the need to make their own decisions in the different activities and tasks proposed [77,78]. The intrinsic motivation of the students should be positively channeled to meet their needs and to enhance them in a way that arouses their interest and curiosity for achieving a desired goal [79]. In this way, disobeying the class rules could be diminished.

A great deal of responsibility lies with the teachers themselves. They should adopt more flexible attitudes towards their students and be more open to understanding their feelings and desires [80], giving them more opportunities to perform tasks [81], using more positive language and inviting them to perform tasks [29], and fostering dependent relationships between themselves and the students [71]. Moreover, a higher teacher competence must contain qualities such as availability, communication, conscientiousness, creativity, feedback, individual consideration, professionalism, problem-solving, and social awareness [8,33].

The role that teaching competence plays in the students' disruptive behaviours is also discussed in this study and, of course, this can also influence the intrinsic motivation.

It should be noted that fun is linked to the perception of intrinsic motivation [82], and that this can get the students to obey the rules more and refrain from continually disrupting the PE class.

The students in our study presented a high level of intrinsic motivation, which is linked to greater disobedience, one of the causes of which might be precisely the lack of fun or feeling of well-being during the classes. In a study conducted on Finnish teenage students, their motivation was linked to fun and their regular adherence to class rules [78]. In another study on a similar sample [79], the boys who felt their self-motivated needs were satisfied and the girls who felt that their relationship needs were met, showed fewer negative experiences and greater autonomy. If there is no fun or satisfaction in the PE class, students may have difficulty controlling their impulses in the classroom environment or towards the teacher. If teachers provide adequate feedback to help modify and improve the proposed task, this will also help to control the perception of the students. There will also be the beneficial response of enhancing positive motivation and satisfaction for teachers and in the classroom environment [78,83]. Therefore, supporting of teacher to student's autonomy is necessary to improve the motivation of students during the PE lessons [12,27,37].

Amotivation or the explanation of an intrinsic motivation in a given situation might be caused by problems in relating to others, leading to a lack of control in a group situation or when interacting with another classmate. The frustration of basic needs when interacting with others, or in the normal development of a group environment, causes rigid patterns of behaviour that affect interactions with others [15,29]. This can lead to continuously stressful situations for the students and, therefore, cause them to avoid achieving a goal proposed by the teacher to protect themselves against any threat to their psychological integrity [15,84]. Therefore, another possible consequence of the relationship between low personal control and interacting with one's classmates could be the stressful situations experienced during PE classes. Finally, a binary model of students and teachers where the interaction between them is closer could minimize possible disruptive behaviours of students because of the relationship created in the classroom´s daily life [85].

5. Conclusions

The results obtained in this study show how disruptive behaviours in secondary school PE students can be produced by the type of motivation they develop, the satisfaction of their basic psychological needs, and by how they perceive teaching competence. Furthermore, our results support the vast majority of previous studies conducted on Spanish adolescent students looking at disruptive behaviours and the effects of motivation, basic needs, and teaching competence. It should be noted that, among all the independent variables addressed in this study, the sex of the students, the perceived teaching competence, and amotivation have been present in all the relationships established with the four disruptive behaviours under study (the dependent variables being: Irresponsibility and low commitment, disobeying the rules, disrupting the class environment, and low personal self-control).

Consequently, future research on samples with similar characteristics to those evaluated in the present study should focus the teaching-learning process on increasing the motivation of PE students. Amotivation is one of the main causes of disruptive behaviours in the class along with the students' perception of teacher competence, which is also important. In addition, boys are more likely to exhibit inappropriate behaviours than girls; this agrees with most national and international studies on similar samples and those looking at PE classes. Therefore, this aspect should be considered by the teacher when dealing with classroom management. It should be noted that this study may be relevant for teachers who intend to take PE sessions with secondary school students.

In summary, the specific training that teachers are given addressing bad behaviours in the classroom must begin in the initial training (university teacher training courses) and continue throughout their professional career in order to respond to the motivational demands and the basic psychological needs of PE students. We also propose working in line with students' needs to respond to their interests and to increase their self-determined motivation. In this regard, it is also important to address the teaching process with current pedagogical models that relate to active methodologies. Finally, we also propose strengthening both the coordinated work between teachers and the tutoring employed when addressing these bad behaviours.

Author Contributions: A.G.-G., M.M.-M., and A.B.-E. conceived and designed the study; A.G.-G. and A.B.-E. performed the analysis; P.J.R.-M., M.M.-M., and A.G.-G. wrote the paper.

Acknowledgments: A special thanks to all the students who participated in this study. Furthermore, thanks to all Secondary schools' participants from Region of Murcia (Spain).

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Psychometric Characteristics of the Physical Activity Enjoyment Scale in the Context of Physical Activity in Nature

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Received: 17 October 2019; Accepted: 25 November 2019; Published: 4 December 2019

Abstract: The aim of this study was to analyze the psychometric properties of the Physical Activity Enjoyment Scale applied to different contexts for initial or original use, such as in the context of physical activity in nature. In order to do this, we carried out a study at some primary and secondary schools located in western Andalucía (Spain), with students aged 9–12 years old (M = 11.22; SD = 1.07). Therefore, a sample of 206 students in Study 1 (98 boys = 47.8%; 107 girls = 52.2%) and 455 students in Study 2 (228 boys = 50.1% 227 girls = 49.9%) was used. The students of the two groups that belong to the study created a program related to Physical Activity in Nature. Descriptive, exploratory, and confirmatory analyses were conducted. We also analyzed several other factors, such as internal consistency, composite reliability, average extracted variance, and convergent validity. Afterward, differences according to gender and school year were also studied. The data showed the need to eliminate many of the items from the original scale, giving, as a result, a model of six items that satisfactorily fit into the confirmatory analysis for the use of physical activity in nature. The ANOVA statistical test, used to analyze sex and school year, did not show any tangible differences between the target groups. Thanks to its application, we note that the PACES instrument cannot be applied as-is; some items must be removed or modified. Therefore, we must obtain a new, more specific instrument for these types of incipient practices undertaken in natural environments.

Keywords: enjoyment; physical activity in nature; outdoor education; teenagers

1. Introduction

We have, in recent years, witnessed an important increase in physical activity levels among the general population [1]. The rise in the number of hours devoted to physical activity, plus the variety of spaces and places where such activities can be carried out, have transformed the outdoors and nature into one of the main environments for this type of activity [2]. Enjoyment and pleasure are some of the reasons behind increases in the practice of physical activity. Enjoyment in the context of physical activity is specifically defined as a positive cognitive or physiologic state that involves feelings of pleasure and fun related to the practice of a physical activity [3]. The outdoors has become an ideal place to escape from society, routine, and life stress, and are thus an ideal place to return to the essence of being oneself. Being in contact with nature also brings with it multiple personal benefits [4]. Twenty-first-century sports practice is also particularly focused on enhancing the experience of strong emotions and exciting sensations, based on the idea that intense enjoyment drives athletes to test their personal limits (challenges) by exploring strange and unusual spaces—in short, searching for adventure and risk [5]. This suggests that people are spending more free time engaging in physical activities in a natural environment; evidence shows that enjoying these natural environments increases our health benefits [6].

Physical activity in nature entails sports–physical activities embodied in educational legislation, which have begun to be practiced in schools with the aim of instilling future habits in the population [4]. One of the main characteristics of these outdoor sport disciplines is enjoyment, which is also one of the central motivations for people to practice sports [7]. Following Scanlan and Symons [8], enjoyment involves feeling pleasure, joy, and fun. In this regard, Granero-Gallegos et al. [9] have shown the relationship, for instance, between students "enjoying sports practice and subjects" through intrinsic motivation (according to self-determination theory [10]), the importance that students attribute to physical education, and, more importantly, the intention of doing physical activity in the future and, therefore, the intention to do physical activity in nature. Enjoyment has been studied from different theoretical perspectives in the search of an explanation for its relationship with physical and sports practice, as enjoyment is perceived to be a key factor in this regard [11]. Therefore, enjoyment has been associated, among others, with perceived athletic competition or with the performance of future physical activity.

A series of instruments have been used to assess enjoyment in physical activity (e.g., the Subjective Exercise Experiences Scale (SEES) [12] and the Enjoyment Scale as a dimension of achievement motivation [13]). In this study, we used the instrument proposed by Molt et al. [14], since it is one of the most relevant models in terms of psychometric results. This instrument includes 16 items and has been adapted for adolescents; a series of studies reveal an interesting relationship between enjoyment and the different versions of intrinsic motivation [15]. Bearing in mind the increase in the number of people doing physical activity in nature, for its competitive, recreational, health, and leisure aspects, we propose the use of Physical Activity Enjoyment Scale (PACES) for school-age youth and adolescents, in the context of physical activity in nature. According to the existing literature, the PACES is an instrument designed for use with physical and sporting activities in conventional sports facilities [16]. Based on our investigations, we advanced the hypothesis that the PACES would perfectly adapt to physical activity practiced in the context of nature and open air and obtained satisfactory results when analyzing the psychometric characteristics of a sample of students aged 9–13 years old [17]. Thus, the object of this study is to analyze the psychometric characteristics of the PACES in a sample of 9–13 years old students in the context of outdoor physical activity practice using confirmatory procedures, along with a gender and school year analysis. It is worth pointing out that these practices use formative and educational approaches rather than sport-related ones [5,18]. Moreover, there is less research on our study variable in the field of physical activity in nature and outside educational contexts.

2. Materials and Methods

2.1. Study 1

2.1.1. Design

In terms of the sample, a non-probabilistic convenience design was applied, based on the subjects that could be accessed. The design used was non-experimental, cross-sectional, and descriptive.

2.1.2. Participants and Procedure

A total of 205 students (98 boys and 107 girls) participated in this study, with an age range of 12–13 years old (M age = 12.22, SD = 0.57), all being 1st and 2nd-year high school students in different educational centers in western Andalusia, Spain. Students, parents, and school management were briefed on the data collection. Once authorizations were obtained, instructions were given, and doubts were dispelled prior to filling in the questionnaires. The questionnaires were answered voluntarily and anonymously upon arrival at the camp site (Albergue Campamento de Andévalo Aventura SLL) in approximately 20 min. The Andévalo Camp is a company with a specialization in Adventure Sport and Physical Activity in the Natural Environment. Further, all students usually go to this camp each year for a period of two to seven days. Consequently, the students know this camp and these activities. Thus, the students should be able to answer this questionnaire from the point of view of physical activity in the natural environment and not from the point of view of sports activities. The researcher insisted on this when it came to responses.

2.1.3. Instrument and Application to the Physical Activity in Nature Context

We used the PACES [15] adapted to a Spanish context by Moreno et al. [16]. This scale measures enjoyment during physical activity through 16 items, which are preceded by the phrase "When I am active ... " This instrument measures enjoyment and bipolar enjoyment, through statements such as "I enjoy it", "I'm bored", "It's very exciting", and "I don't like it". The answers were collected on a Likert scale from 1 (totally disagree) to 5 (totally agree).

This application was analyzed by a group of four experts (Lynn, 1986) in education and physical activity in nature in order to ensure the appropriate design of the items for what the construct was intended to measure; in this way, the original meaning was maintained [19]. These experts were given a table with the item specifications [19], which collected the semantic definition of the construct to be assessed and that of its component. Next, they were shown the list of items after they were adapted so that they could give their opinion on the items' suitability and understandability on a scale from 1 (totally disagree) to 4 (totally agree). Furthermore, they were provided a section to write general notes and observations on each of the items and compose an alternative version for each item if they saw fit. The items with <2.5 mean scores, both in terms of suitability and understandability, were revised. If an item was not classified by at least three of the four experts within the theoretical dimensions of the scale, it was revised again to analyze potential problems before proposing alternative wording that would cover the theoretical dimension in a more clear and accurate way. Bearing in mind that this scale was created by the author, this scale has two dimensions of seven items each, which is the theoretical dimension to which each item belongs. The overall agreement of the four experts on the suitability and understandability of the items was measured using the intraclass correlation coefficient (ICC) based on a mixed effects model and assuming an absolute agreement definition; the values obtained were ICC = 0.77 in suitability and ICC = 0.80 in understandability.

Furthermore, the interquartile range was the standard used to measure dispersion among the four experts' agreements. If the difference between percentile 3 and percentile 1 equaled 0 or 1, the item was accepted and/or slightly modified; if this difference was between 1 and 2, the item was revised and reformulated, and if it was higher than 2, the dispersion between experts was too high, and the item was rejected. Finally, the experts' comments on the instructions and their wording resulted in minor changes. Once all changes requested by the experts had been made, the final version was administered to sixty-five 12–13-year-old high school students. They confirmed their full understanding of the items, and, after a final revision by the research team, we obtained the final version of the PACES adapted to physical activity in nature. This instrument will be only applicable to activities in the natural environment, carried out in that context. Thus, people who are going to respond to this questionnaire should be immersed in nature.

2.1.4. Data Analysis

The psychometric properties of the Physical Activity Enjoyment Scale adapted to physical activity in nature for school students were analyzed through the statistical analysis of the items (i.e., an exploratory factor analysis) SPSS Statistics 21.0 software (IBM, University of Chicago, USA) was used for data analysis.

2.2. Study 2

2.2.1. Design

In terms of the sample, a non-probabilistic convenience design was used, based on the subjects that could be accessed. The design we used was non-experimental, cross-sectional, descriptive, and exploratory.

2.2.2. Participants and Procedure

A total of 455 students (228 boys and 227 girls) participated in this study, the age range being 9–13 years old (M_{age} = 11.22, SD = 1.07); all were primary school students (5th and 6th year) and 1st and 2nd year high school students in different educational centers in western Andalusia, Spain. Students, parents, and school managements were briefed on data collection. Once authorizations were obtained, instructions were given, and doubts were dispelled prior to filling in the questionnaires. The questionnaires were answered voluntarily and anonymously upon arrival at the camp site (Albergue Campamento de Andévalo Aventura SLL) in approximately 20 min.

2.2.3. Instrument

We used the Physical Activity Enjoyment Scale (PACES) adapted to physical activity in nature described in Study 1.

2.2.4. Data Analysis

We carried out a confirmatory factor analysis (CFA), and reliability was measured through Cronbach's alpha. Average variance was extracted, and composite reliability and McDonald's ω were also estimated. Convergence validity and gender invariance, as well as gender and school year differences, were measured with Student's t and ANOVA tests. Data analysis was carried out with SPSS Statistics 21.0 and LISREL 8.80 [20].

3. Results

3.1. Study 1

3.1.1. Descriptive Analysis

First, we carried out an analysis of each of the items in the scale following the suggestions of Carretero-Dios et al. [21]. In line with the contributions of Nunnally et al. [22], we analyzed whether the internal consistency of the scale increased with the elimination of any of the items, and the uniqueness necessary to keep an item inside a factor was studied. The corrected item-total correlation (C-ITC), coefficient, standard deviation (SD), and all answer options were used at some point. Moreover, skewness and kurtosis indices had to be close to 0 and <2 for these items to be accepted. Initially, we tried using only one factor, as done in the original versions of the study, but the data were not satisfactory (the Cronbach's alpha value even less so). Consequently, we opted to distinguish between two factors: a negative valency and a positive valency of enjoyment (Table 1).

An analysis of the items and factors revealed that the alpha values are acceptable. Despite this, the SD results obtained for many of the items have problems (Items 1, 2, 3, 4, 7, 8, 9, 12, 13, and 15), as their values range between 0.770 and 0.957. Furthermore, the skewness values of the negative enjoyment items are above 2.21, and their kurtosis values are above 4.11. For positive enjoyment, many of the items (1, 4, 8, 15) show skewness (−2.38 to −2.92) and kurtosis values (3.24 to 9.39), which suggests that they should be eliminated. However, it is worth noting that the alpha value of each factor did not increase if the problematic items were deleted. Furthermore, the C-ITC of all the items showed values ≥0.32, so we assumed the possibility of using these items in the scale.

Table 1. Descriptive, internal consistency and homogeneity statistics (n = 205).

Scale:	M	SD	CCIT-c	α without ítem	Asymmetry	Kurtosis
Positive Enjoyment (α = 0.786)						
1. I enjoy it	4.67	0.770	0.51	0.76	−2.92	9.39
4. I find it pleasant	4.39	0.948	0.50	0.76	−1.75	2.87
6. It gives me energy	4.12	1.13	0.53	0.76	−1.31	0.983
8. It's very exciting	4.46	0.916	0.57	0.75	−1.86	3.24
9. My body feels good	4.31	0.957	0.54	0.76	−1.50	1.85
10. I get something extra from it	3.87	1.19	0.45	0.77	−0.880	−0.030
11. It´s very exciting	3.97	1.23	0.45	0.77	−1.05	0.150
14. It produces strong feelings in me	3.23	1.35	0.32	0.80	−0.319	−0.960
15. I feel good	4.60	0.792	0.55	0.76	−2.38	5.97
Negative Enjoyment (α = 0.700)						
2. I´m bored	1.46	0.906	0.42	0.66	2.23	4.94
3. I don´t like it	1.35	0.857	0.39	0.67	2.75	7.36
5. It´s no fun at all	1.41	1.04	0.39	0.67	2.59	5.77
7. It depresses me	1.32	0.885	0.47	0.65	2.96	8.11
12. It frustrates me	1.35	0.881	0.46	0.65	2.76	7.22
13. It´s not at all interesting	1.31	0.839	0.35	0.68	2.91	7.98
16. I think I should be doing something else	1.49	1.00	0.39	0.67	2.21	4.11

3.1.2. Exploratory Factor Analysis (EFA)

An EFA for one factor was carried out, and the data ruled out this structure. Therefore, a two-factor EFA solution was carried out using principal component analysis (PCA), requiring a 0.40 minimum correlation for each item important within a factor [23]. The Kaiser–Meyer–Olkin measure was adequate (0.89), and Bartlett's test was statistically significant (χ^2 = 1658.55, $p < 0.000$), all of which verified the suitability of the EFA. The results confirm the two-factor extraction (Table 2). However, the explained variance was low, with a 39.2% value for the total scale.

Table 2. Rotated component matrix (n = 205).

Scale:	*F1*	*F2*
Positive Enjoyment (α = 0.786)		
1. I enjoy it		0.411
4. I find it pleasant		0.518
6. It gives me energy		0.585
8. It´s very exciting		0.537
9. My body feels good		0.581
10. I get something extra from it		0.715
11. It´s very exciting		0.597
14. It produces strong feelings in me		0.554
15. I feel good		0.440
Negative Enjoyment (α = 0.700)		
2. I´m bored	0.549	
3. I don´t like it	0.531	
5. It´s no fun at all	0.505	
7. It depresses me	0.685	
12. It frustrates me	0.625	
13. It´s not at all interesting	0.479	
16. I think I should be doing something else	0.560	

3.2. *Study 2*

3.2.1. Confirmatory Factor Analysis

Structural equation modeling was applied to study the psychometric properties of the PACES adapted to its original physical activity in nature dimension. A series of absolute and relative fit indices were estimated to assess the models [24,25]. For the absolute fit indices, we used the p value associated with the Chi-square statistic (χ^2), the ratio between χ^2 and degrees of freedom (d.f.) (χ^2/d.f.), and GFI (goodness-of-fit index). For the relative indices, we analyzed the NNFI (non-normed fit index) and CFI (comparative fit index). The RMSEA (root mean square error of approximation) was also estimated as the incremental index. The parameters are considered significant when the associated t value is above 1.96 ($p < 0.05$).

First, a multivariate normal distribution analysis was carried out for this scale using a normality test based on the relative multivariate kurtosis (RMK) of PRELIS, LISREL 8.80. The PACES normalized multivariate kurtosis was 32.4 (Mardia–Based–Kappa = 0.726). The critical test value was 1.96 (5%). The test results rejected multivariate normality, which implies the use of robust estimators. In light of this, we used the weighted least squares (WLS) method in LISREL 8.80 [20]. The polychoric correlation matrix and the asymptotic covariance matrix were used as input for data analysis. A two-factor measurement model was hypothesized. The calculations revealed that the RMSEA values, as well as some of the factor loads (item 14 = 0.37) and individual reliability ($R^2 > 0.50$) of many of the items were not suitable (Table 3). Following Byrne [26], the items with high values in standardized residuals (>±2.58) were considered for potential elimination.

Table 3. Items individual reliability (n = 455).

Scale:	Load	R^2
Positive Enjoyment (α = 0.786)		
1. I enjoy it	0.79	0.624
4. I find it pleasant	0.67	0.455
6. It gives me energy	0.65	0.423
8. It´s very exciting	0.77	0.600
9. My body feels good	0.66	0.429
10. I get something extra from it	0.49	0.238
11. It´s very exciting	0.55	0.307
14. It produces strong feelings in me	0.37	0.140
15. I feel good	0.80	0.632
Negative Enjoyment (α = 0.700)		
2. I´m bored	0.66	0.435
3. I don´t like it	0.71	0.500
5. It´s no fun at all	0.67	0.455
7. It depresses me	0.76	0.580
12. It frustrates me	0.70	0.486
13. It´s not at all interesting	0.65	0.423
16. I think I should be doing something else	0.62	0.386

These data, plus those in Table 1, support eliminating items with low values. The CFA values were χ^2/d.f. = 4.75; $p < 0.000$; RMSEA = 0.09; ECVI = 1.223; NNFI = 0.950; CFI = 954; IFI; 0.954; GFI = 0.881. Thus, following Markland [25] and Levy and Hancock [27], we carried out a series of analyses of different models, as suggested by the data, and the items with a low factor load and low R^2 were eliminated. The final result was a PACES-Outdoor Physical Activity (OPACT) with a two-factor model of six items whose EFA values were: χ^2/d.f. = 0.65; $p < 0.000$; RMSEA = 0.005 (IC90% = 0.004, 0.006); ECVI = 0.057; NNFI = 1.002; CFI = 1.00; IFI = 1.001 and GFI = 0.998 (Table 4).

Table 4. Items' individual reliability (n = 455).

Scale	Load	R^2
Positive enjoyment (α = 0.712)		
1. I enjoy it	0.74	0.552
8. It's very exciting	0.75	0.560
15. I feel good	0.84	0.702
Negative enjoyment (α = 0.716)		
3. I don't like it	0.73	0.560
7. It depresses me	0.80	0.640
12. It frustrates me	0.75	0.566

Table 4 shows the fit indices of the two-factor six-item model, which was the only one with the minimum requirements to guarantee convergent validity [28] high standardized factor loads (>0.60), which are statistically significant (t-value > 1.96). Finally, in light of the low alpha values in the ordinal EFA of the scales in the correlation matrix, we also provide the EFA composite reliability and average variance extracted (AVE) values for each dimension (Table 5). The AVE reflects the total variance of the indicators collected by the latent construct; the higher the value, the more representative the indicators of the critical dimension to which they are loaded, considering the limitations of Cronbach's alpha [29], especially when the variables include a low number of items [30] (like the case of the instrument analyzed in this study). McDonald's ω was calculated to measure reliability since, unlike the alpha coefficient, McDonald's ω takes into account the factor loads. Thus, the calculations are more stable and reflect the actual reliability level regardless of the number of items in the variable [29]. Internal consistency values (α) are considered suitable when they are in the 0.70–0.90 range [31].

Table 5. Scale reliability and validity.

PACE—Five Item Model	Convergent Validity	AVE	Cronbach´s Alpha	McDonald's ω
Positive Enjoyment	0.82	0.60	0.85	0.83
Negative Enjoyment	0.75	0.60	0.85	0.80

In terms of convergent validity, the validity of indicators can be assessed based on the size of factor loads [32]. Thus, the NFI was 0.943 for the 16-item scale, whereas for the six-item instrument, this value was 0.998. The AGFI was 0.843 for the 16-item model and 0.991 for the five-item model. Moreover, as mentioned above, saturation was, in all cases, statistically significant (t-value > 1.96), which means that all indicators assess the same theoretical construct [33]. Finally, it is worth noting that all the items have high factor loads (R^2 > 0.50).

3.2.2. Gender and School Year Differences

Next, in order to analyze gendered differences, we carried out a Student's t-test for the independent samples and an ANOVA to study school year differences. As seen in Table 6, no gender differences were found for the positive and negative enjoyment of the PACES in any of the independent variables, such as years.

Table 6. Variance analysis according to gender and school year.

PACES	Male (n = 228)		Female (n = 227)				5th Primary (n = 20)		6th Primary (n = 389)		1st ESO (n = 17)		2nd ESO (n = 29)			
	M	SD	M	SD	F	p	M	SD	M	SD	M	SD	M	SD	F	p
Positive Enjoyment	4.61	0.62	4.53	0.68	1.81	0.18	4.62	0.55	4.58	0.65	4.15	0.86	4.66	0.52	2.59	0.052
Negative Enjoyment	1.28	0.73	1.39	0.80	2.25	0.13	1.25	0.66	1.33	0.74	1.47	0.72	1.37	0.67	0.317	0.813

3.2.3. Invariance Analysis

A gendered invariance analysis was carried out (Table 7) to simultaneously test the equivalence of the factor structure of both sub-groups. No significant differences were found between Model 1 (model with no restrictions) and Model 2 (invariance in measurement loadings) (p = 0.536) or between Model 1 and Model 3 (invariant structural variances and covariances) (p = 0.378). However, statistically significant differences were observed between Model 1 and Model 4 (invariant measurement residuals) (p = 0.037). According to Byrne [26], the absence of statistically significant differences between Model 1 and Model 2 constitutes a minimum standard to accept the existence of invariance in the model, in this case, in terms of gender. Moreover, the decrease in the CFI values was also taken into account; they were <0.1 (ΔCFI contrast test) across the different models. Thus, following Cheung and Rensvold [34], the model was proven to be gender invariant.

Table 7. Multigroup invariance analysis in relation to the gender variable.

Models	χ^2/df	$\Delta\chi^2$	Δgl	CFI	TLI	GFI	RMSEA (IC 90%)
Model 1	0.65	–	–	1.00	1.00	0.99	0.005 (0.004–0.006)
Model 2	0.96	12.05	12	1.00	0.98	0.98	0.006 (0.005–0.007)
Model 3	0.90	23	21	1.00	0.97	0.98	0.006 (0.005–0.007)
Model 4	0.98	77.37	18	0.99	0.97	0.98	0.007 (0.006–0.008)

Note: χ^2 = chi-squared; df = degrees of freedom; CFI = comparative fit index; TLI = Tucker–Lewis index; SRMR = standardized root-mean-square residual; RMSEA = root-mean-square error of approximation.

4. Discussion

The main objective of this work was to analyze the psychometric characteristics of the PACES scale in the context of physical activity in nature for a group of primary and secondary physical education students. We have followed the process set out in Crocker et al. [35] related to the usefulness of this scale to measure enjoyment in different physical education areas; that is, we have used a bi-dimensional fit model for the construct.

Physical activity in nature is included in the physical education classes that the students in this study engage in during school hours [5]. These activities include orientation, hiking, outdoor games, gymkhanas, knotting, climbing, mountain biking, etc. [36]. Furthermore, other studies have proven the beneficial effects of these types of activities for students when physical activity is undertaken outdoors, as this change in environment improves aspects like satisfaction and fun in class, self-perception, and even social goals [37–40]. Consequently, it is essential to use the new instrument in this study since it will help promote the advancement of knowledge in the field of outdoor physical activity, physical education, and sports–physical activity.

The analyses carried out have shown that the original 16 item scale is not able to meet the objective of analyzing students in this context; thus, it is necessary to reduce the scale. First, the descriptive internal consistency and homogeneity values clearly demonstrate the need to modify the scale by eliminating some of the items that showed problems. This was then confirmed by the CFA, which clearly showed that the scale had to be reduced in order to fall within the fit indices' acceptable values, and many of the items had factor loading and individual reliability problems. This reduction in the scale is also interesting for primary school students since, for them, it would be more suitable to assess variables through six rather than 16 questions if the results allowed for this, and their answers are likely to be more reliable in relation to longer questionnaires.

Another relevant aspect is that the scale did not show a good fit for one factor based on the original Molt et al. [15] version adapted to Spanish by Moreno et al. [16]. It should be noted that in other studies [41], the factorial structure of the scale was not analyzed, necessitating its future analysis in later works using broader samples.

However, another study [42] performed this analysis with the adolescent population, also finding problems in their one-dimensional adjustment. Their results [36] confirmed this one factor structure with the inactive adult population and obtained good values. In the present case, both the exploratory and, especially, the confirmatory analysis only allowed a two-factor version of enjoyment by distinguishing between positive and negative enjoyment.

For the ANOVA and invariance analyses, no gendered or school year differences were found. In terms of gender, enjoyment constitutes a particularly relevant factor in the study of behavior in physical activity, as enjoyment has been consistently shown to be related to female participation [28,43,44]. There are different studies that show that girls' concern is to shoot boys; the scientific literature has previously shown that part of girls' concerns when it comes to physical activity is not the enjoyment of physical activity but to perceive a better physical appearance along with controlling your weight. This leads them to not pay attention to enjoyment while doing physical activity, either in nature or outside it [45]. Along the same lines, another investigation [46,47], showed how student boys, unlike student girls, obtained better scores referring to levels of enjoyment when doing physical activity. Another reason is the critical moment of the transition from primary to secondary. However, in our research, there were no significant differences between boys and girls. Moreover, other authors [48,49] hold that enjoyment is a consistent predictor of physical activity among teenage girls. Recent studies confirm that girls have statistically lower levels of enjoyment and physical activity [18]. This lack of significant differences might be related to various factors.

Another factor is that a large part of the sample was made up of primary school students, and it is worth noting here that in this education stage, physical activity in nature is less frequent than in secondary school. This means that students have covered fewer subjects (physical activity in nature does not exist as such in primary school and is included only through games and sports); therefore, there is a very low level of gendered differences. Likewise, primary school teacher training courses are different from secondary education teacher training. Sports Science degrees include compulsory outdoor activity training [50,51], as opposed to primary school teacher degrees, where (in most cases) this subject is not taught. The training courses received by secondary school teachers address the contents of physical activities in the natural environment, unlike those of primary school teachers, for whom such courses are non-existent. This means that physical activity in natural contexts is virtually absent throughout primary school, except when teachers are particularly interested in this field, hence the difficulty in finding significant differences.

5. Conclusions

To conclude, it is worth noting that the PACES-OPACT (Outdoor Physical Activity) model has partially verified the hypothesis that it has not been fully adapted; thus, it has been necessary to create a six-item model. This model has a very good fit, as demonstrated by the CFA, and has high reliability and validity (see Table 5). The convergent validity values also provide these data with robustness.

This instrument advances the field of existing research in several ways:

(1) An instrument is applied in a different context than it was created for, which is the natural environment.
(2) From this application, it is concluded that the PACES, in this context, cannot be applied as-is. Instead, some items must be eliminated and/or modified. Therefore, we obtained a new specific instrument for this type of practice.
(3) An invariance analysis was carried out, something that had never before been done using any of these instruments. Therefore, new data are provided.
(4) Finally, sex and course analysis were performed and have not been differentiated, something that gave different results in other works.

However, in terms of potential future perspectives, it would be good to contrast these results by differentiating a primary school sample and a secondary school sample from physical activity in nature taught exclusively at schools or exclusively outside schools [52]. It is important to note that the location of schools and the extra-mural outdoor activities that students may engage in, such as scouting groups, as well as closeness to natural environments, change the vision and knowledge of these elements [53]. Thus, we believe that although these data fully support this model's application, it would be interesting to contrast these results with those of future studies.

Author Contributions: Conceptualization, J.F.-G., J.S.-P., and A.B.-E.; methodology, J.F.-G., J.S.-P., and A.B.-E.; formal analysis, J.F.-G., J.S.-P., and A.B.-E.; resources, J.F.-G., J.S.-P., and A.B.-E.; writing—review and editing, J.F.-G., J.S.-P., and A.B.-E.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Academic Effects of the Use of Flipped Learning in Physical Education

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Received: 26 October 2019; Accepted: 3 December 2019; Published: 31 December 2019

Abstract: The technological characteristics of today's society have favored the inclusion of information and communication technology (ICT) and the emergence of new training methodologies in educational spaces. This study addresses flipped learning as an innovative approach in the teaching and learning processes of physical education at two educational stages, primary and secondary education. The objective of this study is to analyze the effectiveness of flipped learning with respect to traditional methodology. A descriptive and correlational experimental research design was used through a quantitative perspective. Two study groups were established, one control (traditional methodology) and one experimental (flipped learning) in each educational stage. A total of 119 students from an educational center in Ceuta (Spain) participated. These participants were chosen intentionally. The data were collected through a questionnaire. The results show that the experimental group obtained better evaluations in the academic indicators, highlighting the motivation, autonomy, and interactions between the different agents. Regarding the effectiveness of flipped learning according to the educational stage, its potential was demonstrated in both stages, highlighting a significant improvement in autonomy in secondary education.

Keywords: educational innovation; digital learning; experimentation; learning impact; didactic benefits; primary and secondary education

1. Introduction

In today's society, there is wide use of information and communication technology (ICT), being part of the usual practice in people's daily lives [1]. In particular, in the field of education, the inclusion of ICT has been reflected in current and innovative teaching processes [2], both in the action of teaching on the part of the teachers [3] and in the way students learn, highlighting the potential offered by educational technology [4].

All the great changes that have occurred in education in recent years have been caused by the use of technology in the service of the educational community [5]. This has encouraged improvements in educational actions, increasing the motivation and availability of a wide list of techno-pedagogical resources [6,7]. Thus, it also encourages better access to content for students [8], who welcome the use of ICT in their training process [9].

In this sense, it can be affirmed that ICT has become a fundamental means [10] for the teaching and learning processes that are currently being developed [11] and the creation of new spaces dedicated to training [12] and development of innovative learning experiences [13]. All this is oriented to the search for quality in education, typical of an era digitalized in all areas [14].

This inclusion of technology in the educational spectrum is necessary so that teaching methodologies can adapt to the times and the concerns of today's students. One result is so-called flipped learning, a methodological approach created by Jonathan Bergmann and Aaron Sams. These experts, in 2012, developed online audiovisual materials with content that students had to learn, allowing all students to access the content and customize their learning at their own pace [15]. Currently, this training method has been gaining increasing popularity, being carried out in numerous classrooms at all educational levels, as it is very practical and effective in instructional processes [16–18]. The novelty of this work is to take the use of flipped learning to an area little explored in emerging methodologies, physical education.

The pedagogical basis of flipped learning focuses on the use of time when students are outside the classroom to interact with the content [19,20]. This is carried out through digital platforms and tools generated by teachers [21–23]. The investment of this approach lies in using the teaching period to develop didactic actions based on the previous experience of students, who interact with the content autonomously through digital channels [24–26]. In this way, greater motivation of students and greater interaction on the part of all participants in education are achieved, as reflected in previous studies [27,28].

Therefore, flipped learning is postulated as an effective training method, demonstrated by the number of studies carried out that record its benefits, such as the high rate of commitment demonstrated by students [29], and improved participation in [30] and motivation toward tasks [31]. In addition, it causes increased self-control and individual regulation of learning by students [32], who adapt and regulate learning at their own pace and according to their own needs [31,33]. This increases peer relationships and greater socialization of everyone involved in the education process [34,35]. It also leads to an improvement in the resolution of problems posed during learning [36,37].

All the benefits presented so far affect learning outcomes [38], showing an improvement in scores obtained by students on assessment tests [39], as well as in the acquisition of competencies and set objectives [40–42]. Therefore, the flipping of learning moments [43] also generates effective empowerment of overturned thinking and critical thinking in students [44–46]. All this causes a positive attitude by students toward learning [47].

In this sense, flipped learning can be considered as a techno-pedagogical approach with a high rate of effectiveness compared to other, more traditional methods [48–50]. In the classical methodologies, every informative channel circulates through the teacher as an indisputable figure of the teaching and learning process [51], disregarding the prominence and limiting the actions of students themselves.

All these reported benefits in the scientific literature can be extrapolated to all the knowledge that students must acquire, especially knowledge that requires a more practical type of action. In this line, physical education becomes an ideal subject in which to develop flipped learning [52]. Specifically, in recent research carried out on physical education students, the potential of this innovative training approach has been demonstrated [53–55].

Consequently, innovation in the subject of physical education is already a reality, as stated by studies of its specialized impact, where various innovative practices are carried out to achieve improvements in academic indicators [56–59].

Justification and Objectives

Given the characteristics of the society in which students develop today, there is a need to innovate and continue implementing new ways of teaching and learning in different subjects of the official curriculum, one of which is physical education. Physical education is precisely a field of study that is currently being highly researched, considering it as a very important element for student development [60,61]

This subject assumes a relevant role due to the increased sedentary lifestyle as a consequence of changes in the daily habits of adolescents due to technology [62]. On this basis, technology should not be considered as negative and harmful to student health, but quite the opposite: we should take advantage of its potential attraction and motivational power [63,64] to awaken in students new attitudes toward physical activity.

It is for this reason that in this work the flipped learning methodological approach is used for the development of physical education sessions, with the purpose of fulfilling the need for education based on new challenges, means, and techno-pedagogical resources that contemporary society offers [65]. Following this line of educational innovation through flipped learning, it must be taken into consideration that its effectiveness will be closely conditioned on the characteristics of the students [66] and its applicability will vary according to the educational stage where it is implemented [67].

The purpose of this study is to follow the line of other recent research confirming the effectiveness of this model of pedagogical innovation [16–18,45–48,68] versus the more classical and conservative styles, which are still used in learning spaces [69]. Specifically, in this work the focus of study is the primary and secondary education stages, as the first stages where students are more in contact with the technology that surrounds them and they have access to [70].

Therefore, the objective of this research is to verify the effectiveness of flipped learning in physical education in the development of traditional training actions, from the perspective of two distinct educational stages, primary and secondary. The following specific objectives are based on this statement:

- To know the variability of the motivation, autonomy, critical thinking, resolution of problems, and use of class time of students according to the methodology used.
- To find out the degree of interaction of students with their peers, their teachers, and the content according to the methodological approach carried out.
- To determine the versatility of the ratings of evaluation tests based on the methodology used.

2. Materials and Methods

2.1. Research Design and Data Analysis

The study was approached from a quantitative point of view, through an experimental design of a descriptive and correlational nature, following the guidelines of the experts [71,72]. To this end, two group typologies were defined, control and experimental, at each educational stage, primary and secondary. In the control group, the teacher developed traditional training, while in the experimental group there was an innovative teaching and learning process based on flipped learning. This establishes that the teaching methodology used assumes the role of an independent variable and the efficacy achieved is raised as the research-dependent variable.

The analysis of the data was carried out using the statistical package for the social sciences (SPSS) version 24(International Business Machines Corporation, New York, NY, USA). Basic statistics such as mean (M) and standard deviation (SD), and other specific statistics such as Fisher's skewness (Skew) and Pearson's kurtosis (Kurt), used to determine the trend in the distribution of the data, are covered in this version. The comparison of means between the control and experimental groups was realized by means of the Student's t-test. Cohen's d and bi-serial correlation (r) were also used to measure the size of the effect. A statistically significant difference of $p < 0.05$ was established throughout the analysis.

2.2. Participants

Since this is an experimental study, it does not require a large volume of participation, as in other studies [73,74]. In this research, the sample was made up of 119 students from an educational center in the Autonomous City of Ceuta (Spain), the particularities of which are shown in Table 1. The focused and concrete context of the participants is justified in the search for differentiating findings with respect to other research carried out on flipped learning, as it is a region with certain characteristics at a social, geographical, multicultural, and inclusive level [75,76].

Particularly, the subjects of study were enrolled in the sixth year of primary education (n = 60, boys = 26, girls = 34, M_{AGE} = 12 years, SD = 1.01) and the fourth year of secondary education (n = 59, boys = 23, girls = 36; M_{AGE} = 16 years, SD = 1.26). The sampling technique for selecting participants was for convenience of a nonprobability nature, due to the ease of access to learners.

Table 1. Study groups by sex and educational stage.

Boys	**Primary Education**	**Secondary Education**
	***n* (%)**	***n* (%)**
Experimental group	16 (59.26)	11 (40.74)
Control group	12 (48)	13 (52)
Subtotal	28 (53.85)	24 (46.15)
Girls	**Primary Education**	**Secondary Education**
Experimental group	14 (43.75)	18 (56.25)
Control group	18 (51.43)	17 (48.57)
Subtotal	32 (47.76)	35 (52.24)

Source: own elaboration.

2.3. Instrument

An ad hoc questionnaire was used to collect the data, taking some validated instruments on the state of the matter [64,77,78]. The questionnaire consisted of 42 items. It was divided into two parts well differences. In the first block, different sociodemographic variables such as gender, age, city of residence, nationality, religion, academic year, repetition of course, learning difficulty, availability of technological resources, type of technological resources, and rating in evaluation tests were collected (only in post-test). In a second block two factors are collected, the attitudinal factor composed of five dimensions (motivation, autonomy, critical, resolution, class time) and an interactive factor composed of three dimensions (teacher, classmates, content).

The inclusion criteria of these dimensions and variables were (a) to formulate items that would allow the collection of social, educational, attitudinal, and interactive data about students; (b) to write items briefly and concisely; and (c) to consider the observations of the experts. The exclusion criteria were (a) to eliminate items that caused confusion or interpretation problems; (b) to avoid a large number of items in the questionnaire; and (c) to avoid similar answers that would cause doubt in the participants.

The items are presented mainly in a Likert response format, on a scale of four valuation points, with one the lowest and four the most positive score.

The instrument was validated both qualitatively and quantitatively. The former was carried out using a Delphi method, made up of 10 doctors from different Spanish universities. The inclusion criteria for selecting experts were (a) experience with and studies on educational technology; (b) specialist in the field of activity and physical education; (c) carrying out innovative practices in their professional development; and (d) in-depth knowledge of flipped learning.

These specialists gave a positive evaluation of the questionnaire (M = 4.98, SD = 0.41, min = 1, max = 6), and offered a series of recommendations to optimize the instrument, based on reducing the number of questions and improving the wording of some of them, with the aim of favoring interpretability and completion of the questionnaire. In turn, the feedback was analyzed by Fleiss' kappa (k) and Kendall's W statistics to determine the concordance and relevance of the judgments made (k = 0.86, W = 0.88). Quantitative cut validation was then carried out using exploratory factor analysis, following principal components analysis (PCA) with varimax rotation. Dependence between the variables was formulated by Bartlett's test of sphericity (2643.52; $p < 0.001$) and relevant sample adequacy was found by the Kaiser–Meyer–Olkin test (KMO = 0.89).

In addition, the internal structure was analyzed by confirmatory factor analysis with the maximum likelihood technique, with statistically significant estimated parameters and those with factor loads greater than 0.56 achieving saturation of latent variables. Various adjustment indices that reached adequate values were used (χ^2/df = 2.09, Goodness-of-fit statistic (GFI) = 0.98, Adjusted goodness-of-fit statistic (AGFI) = 0.97; Comparative fit index (CFI) = 0.96, Normed-fit index (NFI) = 0.97, Tucker-Lewis Index (TLI) = 0.98, Root mean square error of approximation (RMSEA) = 0.043), revealing a sustainable model.

Finally, the results obtained for each of the analyzed dimensions are presented, both of the attitudinal factor (Table 2) and the interactive one (Table 3). The results show good reliability indices, the total of the scale being an α value of 0.86, composite reliability of 0.84, and average variance extracted of 0.82. Similarly, no convergent validity problems Average Variance Extracted (AVE) > 0.5 or discriminant, Maximum shared squared variance (MSV) > AVE were observed.

Table 2. Reliability and validity indices for the attitudinal factor.

Variables	α	CR	AVE	MSV	Motiva	Auton	Critical	Resolution	Class Time
Motivation	0.901	0.814	0.611	0.580	0.880				
Autonomy	0.905	0.908	0.601	0.470	0.511 *	0.719			
Critical	0.873	0.815	0.582	0.134	0.341 *	0.251 *	0.792		
Resolution	0.890	0.901	0.712	0.529	0.747 *	0.610 *	0.264 *	0.791	
Class time	0.901	0.921	0.604	0.417	0.611 *	0.582 *	0.271 *	0.703 *	0.713

* Significant correlation $p < 0.001$. Source: own elaboration. CR: Composite Reliability, AVE: Average Variance Extracted, MSV: Maximum shared squared variance.

Table 3. Reliability and validity indices for the interactive factor.

Factor	α	CR	AVE	MSV	Teacher	Classmates	Content
Teacher	0.903	0.815	0.613	0.215	0.899		
Classmates	0.901	0.812	0.807	0.631	0.384 *	0.898	
Content	0.899	0.843	0.625	0.510	0.311	0.804 *	0.766

* Significant correlation $p < 0.001$. Source: own elaboration.

2.4. Procedure

The first phase of the research was to validate the questionnaire designed specifically for this study, which originated in March 2019. Once the validity of the instrument was reached, the second phase consisted of intentional selection of the participants, through contact by the researchers with the physical education department of an educational center in the region previously described. The professionals of this department showed total interest in and collaboration with the study. The third phase was based on configuration of the analysis groups, which was random, as the school has two lines (A and B), resulting in group A, control, and group B, experimental. The fourth phase was based on the teaching of a didactic unit, in which group A followed a traditional methodology without the use of ICT resources and group B an innovative one by means of flipped learning, in its formative aspect of situational investment. This modality is based both on watching videos in the classroom and on the use of didactic software to improve the assimilation of content [21–23]. After the teaching unit, the last two phases of the study took place. Data collection was carried out in a room of the educational center, isolated from outside noise and with good lighting and ventilation, in order to ensure that the participants filled out the questionnaire in the best conditions. All the information obtained was treated following the ethical principles of research. Through a consent form, students were informed that their data would be treated in a manner that would preserve their anonymity, privacy, and confidentiality. Finally, all the information was exported to the statistical program for in-depth analysis.

3. Results

The results in Table 4 contain the scores obtained for the control groups (traditional methodology) during the application of the teaching unit in each educational stage. In general, the results obtained for the control group are very low. Of the nine variables analyzed, only one in primary education exceeded the central score (M ≥ 2.5) in the secondary stage. In primary education, no variable exceeded the central score. The variables with the highest score in the traditional methodology were the use of class time in primary education and the resolution of problems in secondary education. The interaction of students with the teacher and with classmates reached very low values.

Table 4. Results obtained for study variables in control group.

Variables		Likert Scale, *n* (%)				Parameters			
		None	Few	Enough	Completely	M	SD	Skew	Kurt
Primary Education	Motivation	10 (33.3)	12 (40)	6 (20)	2 (6.7)	2	0.89	1.19	−0.5
	Autonomy	12 (40)	11 (36.7)	5 (16.7)	2 (6.7)	1.9	0.91	0.99	−0.34
	Critical	7 (23.3)	13 (43.3)	7 (23.3)	3 (10)	2.2	0.91	1.32	−0.61
	Resolution	6 (20)	10 (33.3)	10 (33.3)	4 (13.3)	2.4	0.95	1.40	−0.94
	Class time	5 (16.7)	9 (30)	13 (43.3)	3 (10)	2.47	0.88	1.66	−0.76
	Teacher	15 (50)	10 (33.3)	3 (10)	2 (6.7)	1.73	0.89	0.82	0.42
	Classmates	10 (33.3)	16 (53.3)	4 (13.3)	0 (0)	1.8	0.65	1.22	−0.73
	Content	6 (20)	13 (43.3)	9 (30)	2 (6.7)	2.23	0.84	1.46	−0.6
	Ratings *	4 (13.3)	14 (46.7)	10 (33.3)	2 (6.7)	2.33	0.79	1.69	−0.4
Secondary Education	Motivation	11 (36.7)	14 (46.7)	3 (10)	2 (6.7)	1.87	0.85	1.02	0.42
	Autonomy	7 (23.3)	14 (46.7)	6 (20)	3 (10)	2.17	0.9	1.3	−0.44
	Critical	7 (23.3)	12 (40)	9 (30)	2 (6.7)	2.2	0.87	1.38	−0.74
	Resolution	5 (16.7)	9 (30)	11 (36.7)	5 (16.7)	2.53	0.96	1.6	−0.93
	Class time	5 (16.7)	13 (43.3)	9 (30)	3 (10)	2.33	0.87	1.53	−0.61
	Teacher	17 (56.7)	10 (33.3)	2 (6.7)	1 (3.3)	1.57	0.76	0.74	1.54
	Classmates	11 (36.7)	13 (43.3)	6 (20)	0 (0)	1.83	0.73	1.13	−1.11
	Content	7 (23.3)	15 (50)	6 (20)	2 (6.7)	2.1	0.83	1.32	−0.18
	Ratings *	3 (10)	13 (43.4)	12 (40)	2 (6.7)	2.43	0.76	1.88	−0.37

* Sample grouping of ratings (min: 0; max: 10) was carried out based on the following criteria: none: 0–4.9; few: 5–5.9; enough: 6–8.9; completely: 9–10. Source: own elaboration.

The scores obtained for the experimental groups (Table 5) reflect the optimal effectiveness of inverted learning. Of the nine variables analyzed, the use of flipped learning allowed them to exceed the central score (M ≥ 2.5) for eight of the variables in primary and secondary education. Interaction with the teacher and with classmates are the most potent variables in both stages, in addition to autonomy in secondary education. In both educational stages, critical thinking is the variable with the lowest score, but it is very close to the central score (M = 2.4 and M = 2.48, respectively).

In Figure 1, a comparison between the groups is made by means of a graph based on the means obtained in the attitudinal dimension. The means obtained for the students of the experimental group (with flipped learning methodology) are higher than those for the students of the control group (with traditional methodology), especially in the variables related to motivation and autonomy.

On the other hand, Figure 2 shows a comparison of the means obtained for the experimental and control groups regarding the interactive dimension. Similar to the attitudinal dimension, the means obtained in the interactive dimension for the group with flipped learning is higher than those for the group with traditional methodology. The greatest difference was obtained with variables related to student interaction (with the teacher and with classmates).

To determine the value of independence between the results obtained for the traditional approach and flipped learning, Student's t-test was carried out (Table 6). A standardized value of $p < 0.05$ was considered a statistically significant difference. As a corrective element for d (correlation force), a distinction for bi-serial correlation ($r = [0, 1]$) was made between small ($r = -0.1$), medium ($r = -0.3$), and large ($r = -0.5$) effect size.

Table 5. Results obtained for study variables in experimental group.

Variables		Likert Scale, *n* (%)				Parameters			
		None	Few	Enough	Completely	M	SD	Skew	Kurt
Primary Education	Motivation	5 (16.7)	6 (20)	11 (36.7)	8 (26.7)	2.73	1.03	1.68	−1.01
	Autonomy	3 (10)	12 (40)	10 (33.3)	5 (16.7)	2.57	0.88	1.78	−0.76
	Critical	5 (16.7)	11 (36.7)	11 (36.7)	3 (10)	2.4	0.88	1.59	−0.74
	Resolution	4 (13.3)	6 (20)	15 (50)	5 (16.7)	2.7	0.9	1.89	−0.5
	Class time	4 (13.3)	8 (26.7)	12 (40)	6 (20)	2.67	0.94	1.77	−0.83
	Teacher	3 (10)	4 (13.3)	14 (46.7)	9 (30)	2.97	0.91	2.16	0.18
	Classmates	2 (6.7)	5 (16.7)	13 (43.3)	10 (33.3)	3.03	0.87	2.32	−0.23
	Content	4 (13.3)	9 (30)	15 (50)	2 (6.7)	2.5	0.81	1.86	−0.49
	Ratings *	3 (10)	11 (36.7)	12 (40)	4 (13.3)	2.57	0.84	1.86	−0.6
Secondary Education	Motivation	4 (13.8)	7 (24.1)	13 (44.8)	5 (17.2)	2.66	0.92	1.8	−0.7
	Autonomy	2 (6.9)	4 (13.8)	11 (37.9)	12 (41.1)	3.14	0.9	2.38	−0.09
	Critical	5 (17.2)	9 (31)	11 (37.9)	4 (13.8)	2.48	0.93	1.59	−0.88
	Resolution	4 (13.8)	6 (20.7)	10 (34.5)	9 (31)	2.83	1.02	1.79	−0.94
	Class time	3 (10.3)	6 (20.7)	12 (41.4)	8 (27.6)	2.86	0.94	1.99	−0.64
	Teacher	3 (10.3)	5 (17.2)	10 (34.5)	11 (37.9)	3	0.98	2.04	−0.63
	Classmates	2 (6.9)	4 (13.8)	12 (41.1)	11 (37.9)	3.1	0.88	2.38	−0.06
	Content	4 (13.8)	8 (27.6)	13 (44.8)	4 (13.8)	2.59	0.89	1.78	−0.67
	Ratings *	4 (13.8)	9 (31)	12 (41.4)	4 (13.8)	2.55	0.89	1.74	−0.73

* Sample grouping of ratings (min: 0; max: 10) was carried out based on the following criteria: none: 0–4.9; few: 5–5.9; enough: 6–8.9; completely: 9–10. Source: own elaboration.

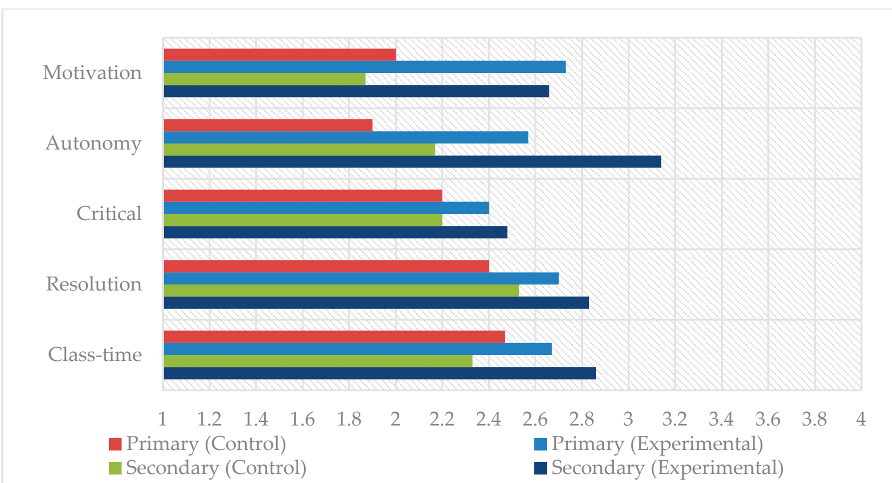

Figure 1. Intergroup comparison in attitudinal dimension.

It has been proven that the flipped learning approach in physical education causes a significant improvement in the interaction of students with teachers and peers. In both primary education ($r = -0.57$, $r = -0.62$) and secondary education ($r = 0.63$, $r = -0.6$), the results confirm an acceptable strength of association. Statistical significance was also obtained in the variables related to motivation and autonomy in both stages, obtaining a medium-low association in primary education ($r = -0.35$, $r = -0.35$) and secondary education ($r = -0.41$, $r = -0.47$), slightly higher for the latter. Finally, it highlights temporary use of the session ($r = -0.28$) and interaction with the didactic content ($r = -0.27$) in secondary education as significant variables, but with little association.

Finally, the results obtained for the experimental groups (in primary and secondary education) were analyzed to determine the value of the independence of flipped learning in physical education according to the educational stage (Table 7). Flipped learning was equally effective in both educational stages. A statistically significant difference was found only in the variable related to student autonomy (higher in secondary education). However, the analysis of effect size ($r = -0.309$) determined that this association in the final reflections should be viewed with caution ($r < -0.5$).

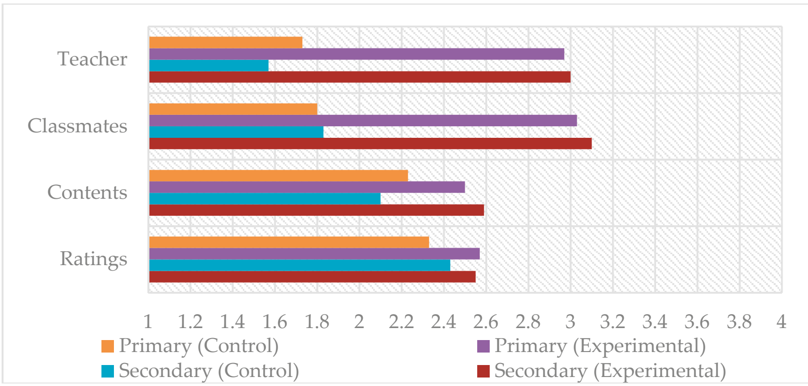

Figure 2. Intergroup comparison in interactive dimension.

Table 6. Study of the value of independence between control and experimental groups.

Variables		Group, M (SD)		$M_2 - M_1$	Student's t		*d*	*r*
		Control	Experimental		*t* (df)	*p*-Value		
Primary education	Motivation	2 (0.89)	2.73 (1.03)	0.73	2.89 (58)	0.005	−0.758	−0.354
	Autonomy	1.9 (0.91)	2.57 (0.88)	0.67	2.55 (58)	0.014	−0.748	−0.351
	Critical	2.2 (0.91)	2.4 (0.88)	0.2	0.85 (58)	0.398	-	-
	Resolution	2.4 (0.95)	2.7 (0.9)	0.3	1.23 (58)	0.223	-	-
	Class time	2.47 (0.88)	2.67 (0.94)	0.2	0.83 (58)	0.408	-	-
	Teacher	1.73 (0.89)	2.97 (0.91)	1.24	5.21 (58)	<0.001	-1.378	−0.567
	Classmates	1.8 (0.65)	3.03 (0.87)	1.23	6.08 (58)	<0.001	−1.602	−0.625
	Content	2.23 (0.84)	2.5 (0.81)	0.32	1.23 (58)	0.224	-	-
	Ratings	2.33 (0.79)	2.57 (0.84)	0.24	1.09 (58)	0.281	-	-
Secondary education	Motivation	1.87 (0.85)	2.66 (0.92)	0.79	3.36 (57)	0.001	−0.892	−0.407
	Autonomy	2.17 (0.9)	3.14 (0.9)	0.97	4.08 (57)	<0.001	−1.078	−0.474
	Critical	2.2 (0.87)	2.48 (0.93)	0.28	1.18 (57)	0.242	-	-
	Resolution	2.53 (0.96)	2.83 (1.02)	0.3	1.12 (57)	0.266	-	-
	Class time	2.33 (0.87)	2.86 (0.94)	0.53	2.21 (57)	0.031	−0.585	−0.281
	Teacher	1.57 (0.76)	3 (0.98)	1.43	6.14 (57)	<0.001	−1.631	−0.632
	Classmates	1.83 (0.73)	3.1 (0.88)	1.27	5.89 (57)	<0.001	−1.571	−0.618
	Content	2.1 (0.83)	2.59 (0.89)	0.49	2.13 (57)	0.038	−0.569	−0.274
	Ratings	2.43 (0.76)	2.55 (0.89)	0.12	0.54 (57)	0.593	-	-

Source: own elaboration. M_1: Mean of the experimental group, M_2: Mean of the control group.

Table 7. Study of the value of independence between experimental groups.

Variables	Group, M (SD)		M_2-M_1	Student's *t*		*D*	*r*
	Primary	Secondary		*t* (df)	*p*-Value		
Motivation	2.73 (1.03)	2.66 (0.92)	−0.07	0.3 (57)	0.764	-	-
Autonomy	2.57 (0.88)	3.14 (0.9)	0.57	2.14 (57)	0.019	−0.64	−0.305
Critical	2.4 (0.88)	2.48 (0.93)	0.08	0.34 (57)	0.732	-	-
Resolution	2.7 (0.9)	2.83 (1.02)	0.13	0.5 (57)	0.619	-	-
Class time	2.67 (0.94)	2.86 (0.94)	0.19	0.78 (57)	0.436	-	-
Teacher	2.97 (0.91)	3 (0.98)	0.03	0.13 (57)	0.895	-	-
Classmates	3.03 (0.87)	3.1 (0.88)	0.07	0.3 (57)	0.765	-	-
Content	2.5 (0.81)	2.59 (0.89)	0.09	0.53 (57)	0.598	-	-
Ratings	2.57 (0.84)	2.55 (0.89)	−0.02	0.06 (57)	0.949	-	-

Source: own elaboration. M_1: Mean of the Secondary group, M_2: Mean of the Primary group.

4. Discussion

The important role of technology in today's society [1] should be to improve the training processes in different learning spaces generated in a digital era [2]. Educational technology must be used from a pedagogical perspective and exported to the different subjects that constitute educational curricula [79]. Thus, the novelty of this study consists in implementing the flipped learning method in the area of physical education, and also, as demonstrated by the beneficial results, developing the subject and acquiring the content by students. In addition, the results may be used to initiate a research path that uses educational stages in general and physical education in particular as incident factors in the use of flipped learning.

In this sense, ICT greatly facilitates the practice of teaching [3] and promotes the assimilation of meaningful and constructive learning by students [4]. In this line, the scientific literature reveals that techno-pedagogical means used in classrooms are beneficial for formative action [5]. In addition, the use of these digital resources enhances the improvement of a set of relevant academic indicators related to student performance and attitudes [6–9].

Therefore, the inclusion of ICT in different learning spaces at all educational stages should be promoted [10,11]. To put this into practice, the experiment presented in this work was developed. This study has allowed us to verify the effectiveness of flipped learning with respect to a traditional methodology in the field of physical education at two educational stages, primary and secondary education. This experiment provides continuity with previous reported works [53–55] verifying the potential of flipped learning as an innovative methodology. This experience also serves to confirm the innovative reform that physical education is undergoing today [56–59]. It should be noted that research analyzing the effects of flipped learning based on the educational stage is very scarce. No specific scientific studies have been reported in the field of education sciences that combine educational levels and physical education. This makes the discussion of results complex, and these cannot be compared directly.

After reviewing previous research, this study analyzed academic aspects such as motivation, autonomy, critical thinking, problem solving, the use of class time, interactions with teachers, peers, and other students, content, and the qualifications of evaluation tests. As has been proven in previous research, these study variables obtained positive evaluations after flipped learning was applied as an educational innovation, in contrast to the results achieved with students with whom a traditional teaching and learning methodology was used.

All academic indicators analyzed in this study obtained better scores for students who completed a training process through flipped learning. Specifically, the results of the present study are analogous with other precedents in variables such as motivation [27,28,30,31,47], autonomy [32], critical thinking, problem solving [36,37], the use of time in the classroom [19,20], teacher–student–content interactions [24–26,34–36], and academic performance [38,39].

Finally, this study shows that flipped learning is equally effective in teaching physical education in both primary and secondary education. Despite this and as mentioned above, these results cannot be debated since there are no specific studies in the scientific literature that analyze the use of flipped learning according to the educational stage of the students. Likewise, this demonstrates the effectiveness of this innovative approach, as stated in the literature [16–18]. Along these lines, its academic potential is verified against traditional teaching and learning methods [48–50].

5. Conclusions

In physical education, the use of flipped learning with students in primary education led to the improvement of all established indicators. Specifically, the most outstanding variables were the interactions of students with the teacher and with their classmates. In secondary education, similar results were found, encouraging the use of flipped learning to improve student interactions with teachers and peers, as well as empowerment of student autonomy in the learning process. On the other hand, the results obtained allow us to verify that the application of flipped learning did not enhance the development of critical thinking in any of the educational stages analyzed. Despite this, it is necessary to highlight that there were slight improvements in this variable with respect to the traditional methodology.

The comparative analysis between the traditional methodology and flipped learning allows us to conclude that flipped learning achieves greater potential in both educational variables, students' autonomy, and interactions with the teacher and other students. Specifically, in addition to secondary education, the temporary nature of the session and the interaction of students with the content were improved.

With regard to the educational stage that achieved better results after the use of flipped learning, it was found that this approach is equally effective in primary and secondary education, highlighting autonomy exclusively as a significantly higher variable in secondary education.

Therefore, this research shows that flipped learning is an effective teaching and learning methodology in physical education. With flipped learning, better results were obtained in various academic indicators than with a traditional methodology that does not use technological resources to impart didactic content. Likewise, flipped learning showed great results in both educational stages, regardless of the level the students are enrolled in. It is concluded that the use of flipped learning in physical education is beneficial for students who are growing up in a digital age.

The expectation derived from the research focuses on the importance of promoting the inclusion of innovative methodologies in teaching and learning processes. In this case, the use of flipped learning brought great benefits in various established academic indicators. This situation demonstrates the potential of technology in today's educational spaces.

The main limitation found in this study was in the digital competence of teachers to generate and impart content from an inverted perspective through the innovative methodology in question. Because the level of knowledge, skills, and digital skills of the teaching staff was not enough, the researchers had to actively collaborate with them. The researchers helped produce the audiovisual materials to deliver the sessions through flipped learning. In addition, the researchers had to recommend various applications, digital resources, and methodological guidelines to carry out flipped learning satisfactorily.

This study can lead to research on the use of flipped learning in physical education in other fields and with other content. The application of this study is totally practical, since it can be part of the daily and habitual reality of students and because it has practical results that can be measured and evaluated in terms of achieving objectives. Physical education specialists can discover a new way of acting in their classes, not only with the use of flipped learning, but also with other emerging methodologies, once their reliability and improvement in results have been proven, as in this case.

In addition to including innovation in the classroom, training and updating knowledge for professional development appropriate to the demands of a digital society should be encouraged. As a future line of study, we intend to analyze the digital competence of teachers who use flipped learning with the purpose of comparing methodological effectiveness with their level of digital skills.

Author Contributions: Conceptualization, F.J.H.L., A.F.C., and J.M.T.T.; methodology, F.J.H.L. and J.L.B.; software, S.P.S; validation, S.P.S.; formal analysis, J.L.B. and J.M.T.T.; investigation, F.J.H.L., J.L.B., A.F.C., J.M.T.T., and S.P.S.; data curation, S.P.S.; writing—original draft preparation, J.L.B. and A.F.C.; writing—review and editing, F.J.H.L., J.L.B., and S.P.S.; visualization, A.F.C.; supervision, F.J.H.L. and J.M.T.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: We acknowledge the researchers of the research group AREA (HUM-672), which belongs to the Ministry of Education and Science of the Junta de Andalucía and is registered in the Department of Didactics and School Organization of the Faculty of Education Sciences of the University of Granada.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Effects of Teaching Games on Decision Making and Skill Execution: A Systematic Review and Meta-Analysis

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Received: 20 December 2019; Accepted: 10 January 2020; Published: 13 January 2020

Abstract: The question of how games should be taught is still a controversial subject. There has been a growing number of studies on teaching games and coaching sports since the first publication of Bunker and Thorpe on Teaching Games for Understanding (TGfU). In this sense, the present systematic review and meta-analysis aimed to systematically review the scientific literature about the effects of technical and tactical approach interventions on skill execution and decision making, and to examine the influence of the teacher/coach management style. A systematic literature search was carried out in accordance with PRISMA guidelines in Web of Science (WOS), PubMed (Medline), Scopus, and SportDiscus electronic databases. A total of seven and six studies were deemed to meet the inclusion criteria for decision making and skill execution, respectively. Meta-analysis results showed that tactical interventions achieved significant improvements in decision making (effect size = 0.89 with 95% confidence interval (CI) from 0.12 to 1.65), but they did not show significant improvements in skill execution (effect size = 0.89 with 95% CI from −0.45 to 2.23) compared to technical approaches. However, the heterogeneity of interventions was large and the quality of evidence was low according to GRADE. In conclusion, tactical approaches are recommended to teach games and sports in order to develop technique, understanding, tactical knowledge, and decision making, which are demanded in game play. These findings could be useful for teachers and coaches to improve these aspects of their players and students.

Keywords: TGfU; sport pedagogy; technique-focused approaches; tactical approaches

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1. Introduction

The best way to teach games is still a controversial subject around the world [1]. Since the first publication of Bunker and Thorpe on Teaching Games for Understanding (TGfU) [2], many studies have been conducted to evaluate the effects of different types of models. Therefore, multiple approaches based on game teaching and coaching have emerged as an alternative to technique-focused approaches aimed at solving the potential problems related to the development of technique at the expense of tactical knowledge and decision making [3]. In technique-focused, traditional, or skill-based approaches, technical skill is pre-determined and based on a perfect model of execution where players execute the skill in a repeatable manner [4] in isolation from the game context and are trained until it is performed well enough to play the game [5]. Moreover, technique-based approaches "focus first on the teaching of the techniques of the game before going on introducing tactical knowledge, once a skilled background has been developed" [6] (p. 40).

This has led to the use of broad terms in tactical approaches or game-based approaches, which, in spite of some small differences, share some common main ideas (they focus on the game as a whole, where they place learning in modified games, and there is an emphasis on questioning to stimulate thinking and interaction) [7]. Some of the better known game-based approaches that follow TGfU are the Tactical Game Approach, Game Sense, Play Practice, Games Concept Approach, Tactical-Decision Learning Model, ball School model, and Invasion Games Competence Model. For these approaches, "the main element is that key learning occurs from the game itself and game-related activities, as opposed to drills completed in isolation then applied during a game" [8] (p. 65). However, tactical approaches underline the complementarity of technical and tactical dimensions of skilled performance [9] and they aim to not only teach the skills required to play a game, but also to allow one to develop the ability to understand the game's tactics and strategies [1]. As stated above, central to the criticisms of the technique-based model was the development of inflexible techniques that did not enable the student or player to resolve real game situations. Therefore, there may be a lack of transfer from practice to games [10]. On the other hand, in tactical approaches, "skill execution is not neglected but developed after understanding the game's strategies and tactics" [11] (p. 30). In this way, these approaches have been related to constructivist and situated learning theories [12], where the student's knowledge construction takes place in games, solving problems, and reflection [13]. Therefore, tactical approaches focus on student learning within a game context and permit people to develop a tactical understanding of the game, tactical awareness, decision making, and skill execution [13].

The research focused on comparing technique-focused and game-based approaches to teach games has increased in recent decades around the world [6,14]. In this way, there has been considerable discussion and research on the most effective method to teach games, and many studies have focused on comparisons of tactical and technical approaches [11].

In the scientific literature, the effects of both types of interventions on several variables have been studied, mainly skill execution and decision making, comparing the two pedagogical approaches (tactical and technical), in order to identify which one can achieve greater results [15]. In this regard, Rovegno et al. [16] highlighted the relationship between motor skill execution and decision making. Nevertheless, previous studies have provided controversial results on the development of skill execution and decision making when technical and tactical models of teaching games are used. Therefore, the up-to-date scientific literature does not provide clear guidelines about the most adequate or optimal approach. In this sense, the comparative approach has much to offer, and it seems clear that there is still a need to identify effective ways to teach students and players in order to develop both game play and participation [11].

To provide clarity on the topic, Oslin and Mitchell [17] published a review of studies evaluating game-centered approaches to teaching and coaching. They highlighted several core concepts to justify the use of this model, including the development of decision making skills and effective decision makers. The central findings section of their review provides an in-depth discussion of the studies comparing technical and tactical approaches. On the other hand, Harvey and Jarrett [14] published a review where they noted that several key challenges remain within game-centered approach research (in-depth inquiry on tactical approaches in coaching contexts, further assessment of tactical awareness development, and the use of longitudinal research designs, among others). These previous reviews have emphasized that results concerning the development of skill execution with tactical and technical approaches are equivocal. In this sense, it is important to emphasize that, in the implementation of technical and tactical approaches, the role of the teacher/coach is very relevant, given that physical education teachers and coaches do not present the same management style (e.g., teacher/coach's personality, communication skills, use of feedback, motivation, etc.). In this sense, there is a lack of information about coaches' behaviors in teaching games.

Therefore, given the interest and relevance of the topic, as well as the controversy about the best way to teach games and the importance of the teacher/coach behavior style, a systematic review and meta-analysis is necessary. Based on previous reviews [6,14,15,17], it can be hypothesized that a tactical approach will result in better learning outcomes than a technical approach in teaching games. However, the magnitude of those differences must be quantified and proper analyses must be conducted to accept or reject that hypothesis. To the best of our knowledge, no meta-analysis of studies comparing skills-based and tactics-based approaches to teaching games has been performed before the current one. In this regard, the purpose of the present systematic review and meta-analysis was to systematically review the scientific literature about the effects of technical and tactical approach interventions on skill execution and decision making, and to examine the influence of the teacher/coach management style.

2. Methods

The Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA) guidelines have been followed to conduct the current review [18].

2.1. Inclusion Criteria

The manuscripts were deemed eligible for inclusion if they met the following criteria: (1) the intervention was based on a comparison of the technical and tactical models in sports education; (2) players or students' decision making and/or skill execution were measured; (3) articles were written in English or Spanish; (4) manuscripts were published in the XXI century; and (5) articles were original research (not a systematic review or literature analysis). To reduce selection bias, each study was independently reviewed by two of the authors (C.F.-E. and M.T.A.R.), who mutually determined whether or not they met basic inclusion criteria. If a consensus could not be reached on inclusion of a study, the matter was settled by consultation with a third author (F.J.G.F.-G.).

2.2. Search Strategy

A systematic literature search was carried out in accordance with PRISMA guidelines [18] in Web of Science (WOS), PubMed (Medline), Scopus, and SportDiscus electronic databases. The search was conducted from the year 2000 to May 2019. The following syntax was used for the search process: ("TGFU" OR "teaching games for understanding" OR "tactical games approach" OR "tactical approach" OR "tactical games model" OR "game centred approach" OR "game sense approach" OR "game based approach" OR "games teaching" OR "constructivis*") AND ("sport" OR "physical education" OR "training") AND ("techniques" OR "technical skills" OR "traditional Model" OR "technical approach" OR "skill-centred approach" OR "instructional model*" OR "instructional method*" OR "instructional coaching") AND ("decision making") AND ("intervention" OR "experimental" Or "quasi-experimental" OR "randomized controlled trial").

2.3. Assessment of Risk of Bias

To evaluate the risk of bias, the PEDro scale [19] was used. This scale was developed to assess the quality of intervention studies, especially randomized controlled trials. The GRADE approach, which involves a four-point scale ("very low", "low", "moderate", and "high"), was used to assess the quality of evidence [20]. In this approach, the quality of the evidence is downgraded when inconsistency, indirectness, imprecision, or publication bias are present. Table 1 shows the risk of bias results of included articles. To evaluate the risk of bias and the quality of evidence, each study was independently reviewed by two of the authors (C.F.-E. and M.T.A.R.). If a consensus could not be reached, the matter was settled by consultation with a third author (F.J.G.F.-G.).

Table 1. Risk of bias according to the PEDro Scale.

	Response to Each Item Level of Evidence											
Study	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total Score**
Guijarro-Romero et al., 2018	Y	N	Y	Y	Y	N	N	Y	Y	Y	Y	7
Ashraf 2017	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
Morales-Belando and Arias-Estero 2017	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
Nathan 2016	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
Gray and Sproule 2011	N	N	N	Y	Y	N	N	Y	Y	Y	Y	6
Psotta and Martin 2011	Y	N	N	Y	Y	N	N	Y	Y	Y	Y	6
Chatzopoulos et al., 2006	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8

Y: criterion fulfilled; N: criterion not fulfilled; 1: eligibility criteria were defined; 2: the participants were randomly distributed to groups; 3: the assignment was concealed; 4: the groups were similar before the intervention (at baseline); 5: all participants were blinded; 6: therapists (teachers) who conducted the intervention were blinded; 7: there was blinding of all evaluators; 8: the measures of at least one of the fundamental outcomes were attained from more than 85% of the participants initially; 9: "intention to treat" analysis was conducted for all participants who received the control condition or treatment as assigned; 10: the findings of statistical comparisons between groups were reported for at least one fundamental outcome; 11: the study gives variability and punctual measures for at least one fundamental outcome; total score: each satisfied item (except the first) adds 1 point to the total score.

2.4. Data Collection

Firstly, two authors extracted data from the included articles. Subsequently, the gathered information was checked by another author. Following the recommendations from PRISMA guidelines, relevant information included participants, intervention, comparisons, results, and study design (PICOS) [21]. Table 2 shows the main characteristics of the different protocols of intervention and the essential participants' characteristics (sex, age, sample size, level of education or setting, and treatment).

Concerning interventions, we summarized the following details: duration, number of lessons, type of intervention program (tactical or technical), and teacher/coach management style analysis. In the study by Guijarro-Romero et al. [22], students received a 5 weeks of learning program, consisting of 10 lessons and 1 h per lesson. Students consecutively performed two teaching units (indoor football and basketball) based on a traditional technical-tactical approach. The tasks administered were more instructive and focused on learning isolated and without connection from one sport to another. Students received fully instructive feedback during the different sessions. With regard to the tactical approach, students carried out an intervention program using alternate teaching units of indoor football and basketball based on a tactical approach. The intervention consisted of carrying out a session of indoor football followed by another of basketball, focusing on establishing a connection in the learning of both sports. The teacher/coach management style was not analyzed.

In the study by Ashraf [23], students received a 2 months of learning program, but the number of lessons was not reported. The technical approach used was the traditional method, and Teaching Games for Understanding was used, although the authors do not describe its characteristics. The teacher/coach management style was not analyzed. On the other hand, the Morales-Belando and Arias-Estero's study [24] lasted 2 weeks, with 11 lessons of 80 min. "Technical group's lessons followed the traditional segments in sailing: (a) The coach taught the knowledge out of the water; (b) the sailors then applied such knowledge to a situation in which they sought to improve skill execution; and (c) finally, the participants practiced in a race" [24] (p. 4). The traditional approach only focused on how to act, so the technical content was taught first and the tasks were stripped of a real race context and the coach told the sailors what they must do. Moreover, the learners had a passive role, carried out the coach's orders, and tried to imitate a perfect technical approach, whereas the coach told them and showed them what and how to do the tasks, while using technically perfect actions [24]. On the other hand, "the TRfU group's lessons were created following the lesson segments: (a) The teacher set up the "race form" so that participants would work on the tactical aspect similar to a real race; (b) the teacher conducted "teaching for understanding" so that the children could reflect on what they had to do and why; (c) the teacher conducted "drills for skill" development so that participants could improve their skill execution; (d) the class returned to the "race form" so that the participants could perform a lesson segment very similar to the initial lesson segment; and (e) the teacher conducted a "review and closure" so that participants could reflect on the integration and understanding of skill execution and decision making" [24] (p. 4). The teacher/coach management style was not analyzed.

Table 2. Characteristics of the participants and the protocol.

Characteristics of the Sample				Protocol	
Study	**Country**	**Sample Size of Groups and Sex**	**Age (SD) and Education Level/Setting**	**Tactical Group Treatment**	**Technical Group Treatment**
Guijarro-Romero et al., 2018	Spain	TEG *: 42 (16 males and 26 females) TAGLIL ***: 23 (7 males and 16 female) In meta-analyses, it only used data from this group TAGHIL: 20 (16 males and 4 females)	10–12 years Primary school	Tactical approach	Technical approach
Ashraf 2017	Romania	TEG: 21 (NR ****) TAG **: 24 (NR)	20 (1.2) 20 (1.9) College students	Teaching Games for Understanding (TGfU)	Traditional method
Morales-Belando and Arias-Estero 2017	South of Europe	TEG: 27 (NR) TAG: 40 (NR) 45 males and 22 females (global data)	9.32 (2.60) (global data) Sailing school	Teaching Races for Understanding (TRfU)	Traditional teaching mode
Nathan 2016	Malaysia	TEG: 16 (8 females and 8 males) TAG: 16 (8 females and 8 males)	15.50 (1.00) (global data) Badminton school	TGfU revised	Skill Drill Technical
Gray and Sproule 2011	Scotland	TEG: 25 (12 females and 13 males) TAG: 27 (11 females and 16 males) * In meta-analyses, it used data on-the-ball "good" for decision making and data "successful" for skill execution	12.50 (0.20) 12.50 (0.30) Secondary school	Game-based approach	Skill-focused approach
Psotta and Martin 2011	Czech Republic	TEG: 12 (females) TAG: 12 (females)	21.00 (0.70) 20.70 (0.80) College students	Technical-tactical model with an emphasis on orientation to tactical	Technical-tactical model with an emphasis on orientation to technical skills
Chatzopoulos et al., (2006)	Greece	TEG: 37 (females) TAG: 35 (females)	12–13 years Middle school	Games approach	Technique approach

* TEG: Technical group; ** TAG: tactical group; *** TAGLIL: tactical group with a low initial tactical level; TAGHIL: tactical group with a high initial tactical level; **** NR: not reported.

In addition, in Nathan's research [25], the students received two lessons per week comprising 40 min per lesson for 5 weeks. In this study, Skill Technical was used, which is a teacher-centered approach based on the practice of skill drill activities of movement skills in an isolated way. This conceptual framework emphasizes the importance of teaching and learning skills prior to game play through skill drill practice [26]. On the other hand, Teaching Games for Understanding was used: Including the performer, environments, and task, where decision making and skill execution are derived from the game concept and thinking strategically. Moreover, Nathan [25] investigated the teachers' reflections and experiences about questioning. In relation to Gray and Sproule's study [27], this research lasted 5 weeks, with five lessons and 60 min per lesson. In this study, the skill-focused approach followed the physical education department's program for teaching basketball. The teacher's overall aim was to develop the pupils' performance in 4v4 games following "his own knowledge and beliefs about teaching to deliver the program set out by the physical education department" [27] (p. 19). The tactical approach used "emphasizes tactical understanding and the development of motor skills as a means of solving tactical problems within a game-practice-game format. The teacher decides on the tactical problem that has to be addressed and presents games and practices that both emphasize the specific tactical problem" [27] (p. 19). The teacher/coach management style was not analyzed.

On the other hand, in the study by Psotta and Martin [28], the students received a 5 weeks of learning program, consisting of 10 lessons and 90 min per lesson. In this study, a technical-tactical model with an emphasis on orientation to tactical skills was used: "the technical skills are taught under controlled conditions in a predictable learning environment, and the tactical skills are taught using an unpredictable environment" [28] (p. 8). On the contrary, in the technical-tactical model with an emphasis on orientation to technical skills, the technical skills are taught in an unpredictable environment, and the tactical skills are taught using a match, with a teacher's verbal instructions being related to tactics [28]. The teacher/coach management style was not analyzed. Finally, the research by Chatzopoulos et al. [29] lasted 5 weeks, and consisted of 15 lessons and 45 min per lesson. In this study, the technique group began the lesson with a demonstration of a specific technique, followed by practice of the technique in a series of drills. Following this, a tactic was taught for 5 min. The teacher introduced a tactical element on a blackboard and then on the game field. On the other hand, the games group began with a modified game designed to stimulate tactical thinking [29]. Next, technique (through drills) and tactical instruction were allocated. The teacher/coach management style was not analyzed.

2.5. Statistical Analysis

In these meta-analyses, a random-effects model was used to measure the effect of interventions based on technical and tactical approaches on decision making and skill execution. Figures 2 and 3 show the results of each study on these variables. The effect size was calculated using means and standard deviations before and after treatment [30]. For these meta-analyses, the magnitude of Cohen's d was specified as follows: (a) "large", for values greater than 0.8; (b) "moderate", when it was between 0.5 and 0.8; (c) and "small", for values between 0 and 0.5. Heterogeneity was evaluated by calculating the following statistics: (a) p-value of Cochran's Q-test and (b) I^2, which is a transformation of the H statistic used to determine the percentage of variation which is caused by heterogeneity. The most common classification of I^2 considers values higher than 50% as large heterogeneity, values between 25% and 50% as average, and lower than 25% as small [31]. The tool Review Manager 5.3 was used to conduct all analyses [32].

3. Results

3.1. Study Selection

Figure 1 (PRISMA flow diagram) shows the complete process followed in the current systematic review. The original search identified a total of 51 manuscripts from the electronic databases: WOS (11), PubMed (4), Scopus (28), SportDiscus (7), and additional records identified through other sources (1). Five of them were removed because they were duplicated. Subsequently, to find any additional articles that met the inclusion criteria [33], the reference lists of articles retrieved and other sources were screened as part of a complementary search. One additional manuscript was found. Of the remaining 46 articles, 30 were removed because they were not connected with the study theme, five because the intervention programs did not have a technical group or only an experimental group, one because it did not conduct baseline evaluations, and three because they were systematic reviews or literature analyses. Therefore, the final number of studies included for meta-analyses was seven and six for decision making and skill execution, respectively (Figure 1).

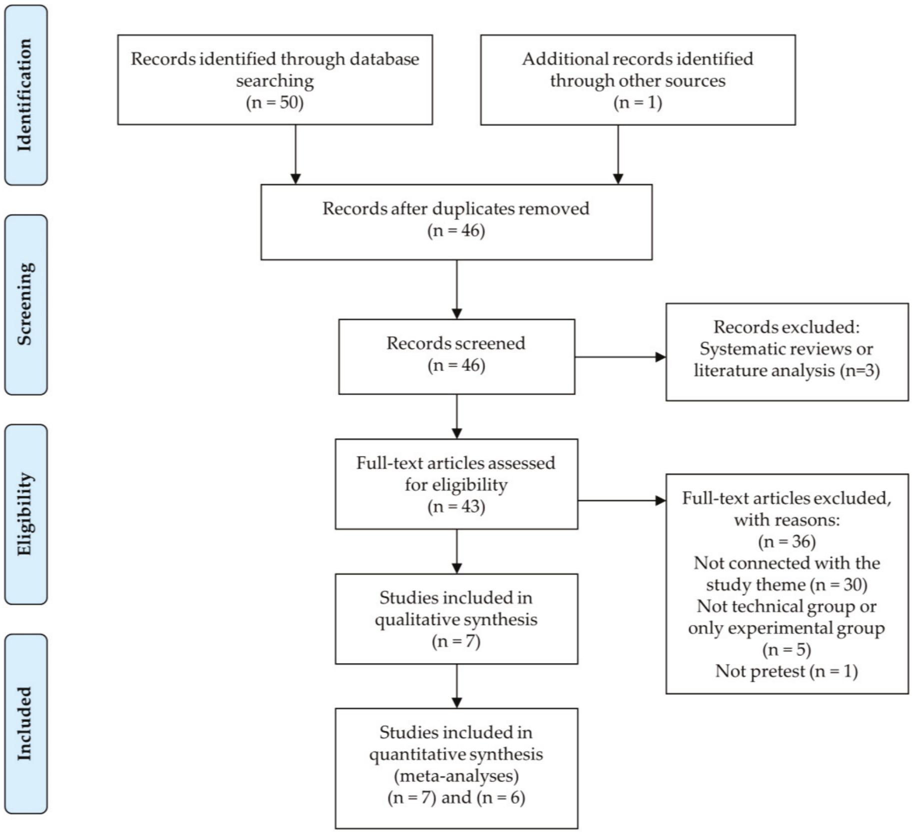

Figure 1. Flow diagram for the systematic review process according to Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA) statements.

3.2. *Risk of Bias*

Table 1 shows the risk of bias of the six selected articles according to the PEDro scale. Scores varied from six to seven [22,27,28] and to eight [23–25,29]. Regarding the quality of evidence, the GRADE guidelines have been followed. In this sense, the quality of evidence was downgraded twice: firstly, due to the high degree of heterogeneity, and secondly, because of the relatively low number of participants in the studies. However, it was upgraded because the total effect size was 1.78 and 1.86 for decision making and skill execution, respectively. Therefore, the quality of evidence according to the GRADE guidelines was “low”, which was defined as “Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect” [20] (p.404).

3.3. *Study Characteristics*

Table 2 shows a summary of the characteristics of the study. There was a total of 357 participants. Of these, 180 were distributed in the technical group (TEG) and 177 were allocated the tactical group (TAG). Two studies were conducted in primary school, one in middle school, one in secondary school, two in a university, one in a sailing school, and one in a badminton school.

3.4. Interventions

The tactical approaches used were the tactical approach, TGfU, Teaching Races for Understanding (TRfU), TGfU revised, game-based approach, and technical-tactical model with an emphasis on orientation to tactical skills. Regarding the technical models, these were as follows: Technical approach, traditional method, traditional teaching mode, Skill Drill Technical, skill-focused approach, and technical-tactical model with an emphasis on orientation to technical skills.

The intervention duration varied between 2 and 5 weeks. The number of lessons ranged between 5 and 15. The study conducted by Ashraf [23] did not specify the number of lessons, and only specified the intervention duration (2 months). Only one study [25] investigated the teachers' reflections on and experiences of questioning.

3.5. Outcome Measures

Figures 2 and 3 show the effects of technical and tactical approach interventions on participants' skill execution and decision making. To evaluate the skill execution and decision making, two articles used the Game Performance Assessment Instrument (GPAI), and another developed an adapted instrument from this: the Race Performance Assessment Instrument (RPAI). Another manuscript used the Game Performance Evaluation Tool (G-PET), only to assess decision making; another used an adaptation of the Game Play Observational Instrument (GPOI); another used a coding instrument (CI); and another used the Soccer Performance Observation System (SPOS) based on GPAI.

As can be seen in Figure 2, the meta-analysis results showed that tactical intervention resulted in improvement compared with the comparison groups in almost every article (see Figure 2) and was significant in five studies [22–24,27,29]. However, the study by Nathan [25] reported no significant difference between TEG and TAG models in terms of skill execution or decision making. The overall effect size for decision making was 0.89, with a 95% CI from 0.12 to 1.65. Following the proposed classification, this effect size was large. The heterogeneity level was large (I^2 = 99%) and the P-value of the Cochran Q-test was <0.01.

Figure 3 shows that two of the six articles reported significant improvements in skill execution relative to the baseline, caused by the tactical intervention [24,27]. One article was removed because it did not evaluate the skill execution [23]. Moreover, no studies reported significant improvements in skill execution because of technical treatment. The overall effect size for skill execution was 0.89, with a 95% CI from −0.45 to 2.23 (see Figure 3). In accordance with the proposed classification, this effect size was large. The heterogeneity level was large (I^2 = 100%) and the p-value of the Cochran Q-test was <0.01. The effects of tactical or technical treatment on participants' decision making and skill execution are shown in Figures 2 and 3.

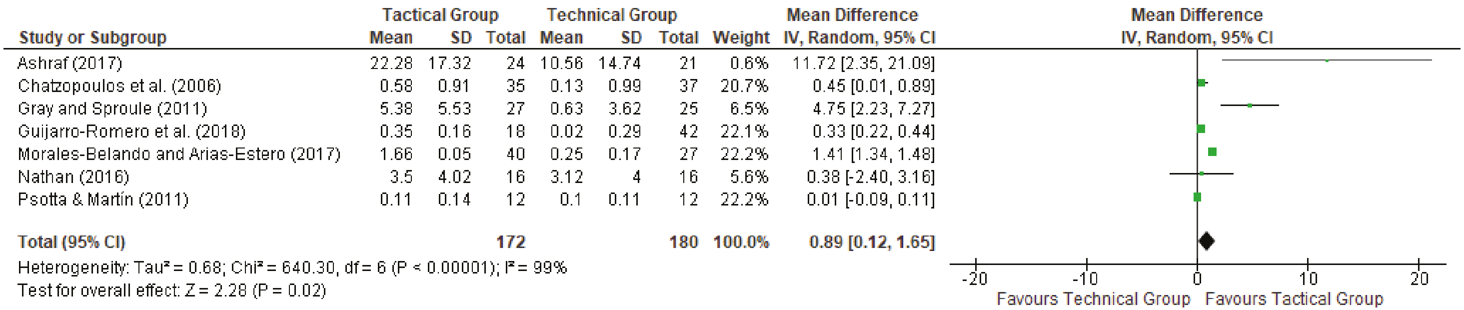

Figure 2. Meta-analysis results of the effects of TEG and TAG on decision making.

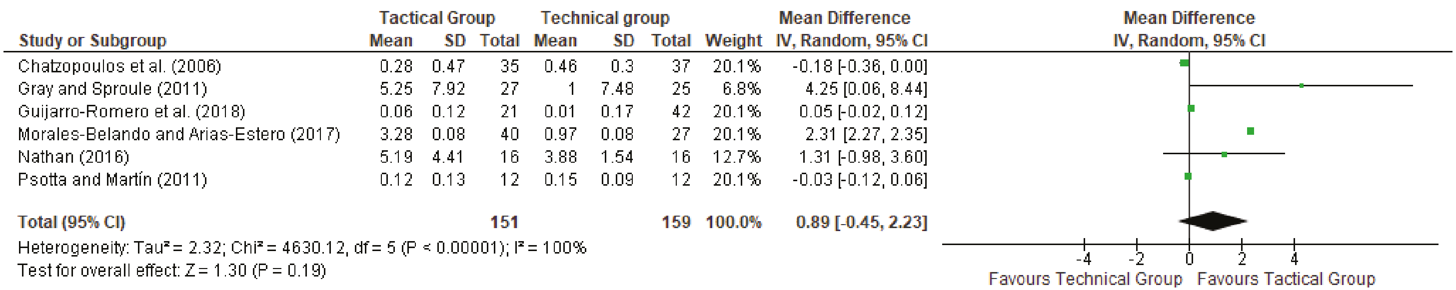

Figure 3. Meta-analysis results of the effects of TEG and TAG on skill execution.

4. Discussion

The present systematic review and meta-analysis aimed to systematically review the scientific literature about the effects of technical and tactical approach interventions on skill execution and decision making, and to examine the study of the influence of the teacher/coach management style. The first main result showed that the tactical approach resulted in a significant improvement in decision making compared to the technical approach. This significant enhancement was observed in five of the seven analyzed studies and can be considered as large, according to the overall effect size (total effect size of 0.89, with a 95% CI from 0.12 to 1.65 and p-value = 0.02). In this regard, researchers consider that a tactical approach can make a significant contribution to the development of several areas of play such as tactical understanding and decision making [34]. However, there is still limited research about whether coaches are aware of the methodologies which may improve tactical understanding and decision making [35].

Another main finding was that the tactical interventions also achieved significant benefits in skill execution. In this regard, the overall effect size for skill execution was 0.89, with a 95% CI from—0.45 to 2.23 and p-value = 0.19. The technical approach did not result in a significant improvement in skill execution in any studies evaluated, but the tactical model resulted in a significant improvement in skill execution in two of six studies. In this respect, Bunker and Thorpe [2] proposed the integration of skills into contextualized situations in an attempt to link tactics and skills within a game context. Therefore, the tactical approach has the potential to facilitate the development of technical skills and tactical knowledge [36]. Therefore, this model may be more adequate to improve not only decision making, but also the skill execution, compared to the technical approach. Accordingly, findings from the current meta-analysis could be useful for teachers and coaches to improve skill execution and decision making among players and students. Nevertheless, due to the large heterogeneity and the low quality of the evidence, interpretation of this meta-analysis must be conducted with caution. In this sense, "more work needs to be undertaken to reinforce and further demonstrate the relationship between game centred training and skill development" [8] (p. 68).

One of the included articles showed very outstanding results in favor of the tactical group in decision making using TGfU [23]. In addition, another study [27] showed outstanding results in skill execution favor of the tactical group. This research, with five lessons of 60 min of duration during five weeks, focused on "tactical understanding and the development of motor skills as a means of solving tactical problems within a game-practice-game format" [27] (p. 19). Given the great effect observed in these studies, future research may focus on corroboration of the benefits of these protocols. In this sense, according to Forrest [13], the actual meaning of employing tactical approaches (and technical approaches) has been little explored and more research is needed to clarify what we really do when we implement these models.

Regarding the characteristics of the successful tactical interventions, the duration of the interventions varied between 2 and 5 weeks, between 5 and 15 lessons, and between 40 and 90 min per lesson. Therefore, according to these results, the benefits of tactical interventions could not be linked to the treatment length. With regards to this point, it is important to note that the implementation of technical and tactical approaches can be problematic, given that it depends on the teacher who is in charge, rather than just the model used [13]. This is more complicated when teachers and coaches think they use an alternative approach and are actually using a traditional method [37].

As can be seen in Table 2 and Figure 2, significant improvements in decision making from tactical models are not related to participants' age or education level/setting. On the other hand, the results showed significant improvements in skill execution using tactical models among secondary students and school sports players (see Table 2 and Figure 3). Therefore, these results showed that tactical approaches can be used to improve skill execution. Nonetheless, it must be noted that the development of tactical and technical approaches is profoundly related to the environment and the fact that each context is different [7]. In this sense, physical education teachers and coaches do not present the same pedagogical characteristics (e.g., use of knowledge in practice and differences in training times) [38]. Moreover, transitioning to tactical approach pedagogy is challenging and can lead to frustration [38].

Concerning the type of sport, there were significant improvements in decision making using tactical approaches in all of them, except badminton [25] and soccer [28]. Regarding skill execution, there were significant improvements in the tactical group for basketball [27] and sailing [24]. It is important to note that the study focused on sailing that achieved significant between-group improvements in decision making and execution in favor of the tactical approach.

To our knowledge, this is the first systematic review and meta-analysis aimed at comparing the effects of technical and tactical approaches in decision making and skill execution, using a strong and widely-accepted methodology (PRISMA) and providing conclusions based on the existing evidence. Although relevant results were observed and a tactical approach can be strongly recommended based on the findings, further studies are needed to increase the quality of the evidence and to clarify what teachers and coaches do when they implement these models. In this sense, in relation to analysis of the influence of the teacher/coach management style, only one study [25] investigated the teachers' reflections on and experiences of questioning. Future research could also examine the teaching and learning processes involved when adopting different approaches to teaching in order to know the effect that teachers' personalities may have on students' learning [29].

Nevertheless, the present systematic review with a meta-analysis has some limitations. First, four studies used the same instrument (GPAI) or an adapted version of it, but the other two–three studies were carried out with other instruments to assess skill execution and decision making (respectively). Second, the literature search was limited to two languages: Spanish and English. Therefore, the risk of the exclusion of manuscripts written in other languages was high. Finally, the meta-analysis showed a high level of heterogeneity, which means that the interpretation of the results of this study must be considered with caution.

5. Conclusions

Tactical approaches can be strongly recommended to teach games and sports in order to better improve skill execution and decision making, which are demanded in game play. In this regard, tactical approach interventions are useful for improving the players' and students' decision making, while technical models may be inadequate. On the other hand, tactical models could have positive effects on skill execution. Nevertheless, there is a lack of information about teacher/coach management style. These findings could be useful for teachers and coaches, but must be considered with caution given the heterogeneity and the low quality of the evidence.

Author Contributions: F.J.G.F.-G. and M.T.A.R. designed and supervised the study; D.C.-M. analysed the data; M.T.A.R. and C.F.-E. wrote the manuscript and interpreted the findings; E.C.V. reviewed the paper. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Effect of the Modification of the Number of Players, the Size of the Goal, and the Size of the Field in Competition on the Play Actions in U-12 Male Football

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Received: 10 December 2019; Accepted: 9 January 2020; Published: 14 January 2020

Abstract: A player's sports development involves a long process. The modification of rules for youth players seeks to adapt the sport to the child and his/her development. The manipulation of rules affects the technical and tactical skills demonstrated by players and, therefore, their development. The objective of this study was to analyse the effect of a reduction in the number of players (from 8 per team to 5 per team), the size of the goal (from 6 × 2 m to 3 × 2 m) and the playing space (from 58 × 38 m to 38 × 20 m), on the technical and tactical actions in youth football players. A quasi-experimental A-B-A design was implemented to assess the effect of the rule changes. The players (n = 40) played three tournaments using two competition formats (official rules, modified rules, and official rules). The results show that the use of the modified rules generated a greater number and variability in the technical–tactical actions, a greater number of actions with teammates in the pass line, a greater continuity in the game, a greater number of attack and defence actions in areas close to the goal, and favours team play. The experimental format fits the players' individual progression better (U-12) as well as the players' and teams' collective development, and it will allow players to evolve from the individual development of previous stages.

Keywords: children; player development; sport; competition; rules; technique; tactics

1. Introduction

Football is a late specialization sport with a long development process [1,2]. During this process, players go through different phases in relation to their biological age and training. For players, the goal of the process is to have appropriate experiences with regard to their level of maturity and skill. The progressive accumulation of these experiences through competition and training is what allows players to increase their performance [3]. For this reason, each stage of the process needs specific game rules that allow for the long-term athletic development (LTAD) of the players [4]. The modification of the rules seeks to adapt the sport to the child and his/her development. The rule modifications seek to increase children's participation through actions that are appropriate for their physical, technical, and psychological characteristics [5–7]. The modification of structural elements of football, such as scoring systems, affects players' mental fatigue [8]. In each country or region, federations or institutions establish competition formats and rules adapted to the players within the formation. For example, in

Spain, the national federation recommends competition formats for each age group, and the territorial federations establish the specific format for each category. However, there is no consensus on the most appropriate format for each age group. There are different proposals focused on the modification of the number of players, the dimensions of the pitch and goals, the playing time, and the manipulation of the offside rule [9–11]. However, the incidence of these modifications on the actions of the game and the adequacy of the game format in the development of the youth player is unknown.

In the specialized bibliography, it is possible to find different theoretical models for the development of the youth football player [12]. These models evolve in the number of players, and the size of the field and goal, progressively (e.g., 3 vs. 3 (U-8), 5 vs. 5 (U-10) and 9 vs. 9 (U-13)). These formats seek to reduce the impact of age-group changes and achieve greater player participation by adapting the rules [12–14]. There are few experimental studies that analyse the effect of rule changes on the player's LTAD. Most of the available information comes from descriptive observational studies. Regarding the manipulation of the number of players, the observational studies show that a reduction in the number of players compared to the 11 vs. 11 format resulted in a greater number of technical–tactical offensive actions [9,10,13,14], greater effectiveness in offensive actions [8], and more depth and breadth in offensive game actions [9,13,14]. In relation to the manipulation of the dimensions of the field, studies have found the importance of the dimensions of the field on players' technical–tactical behaviours [15]. An increase in the area per player involves a greater number of technical–tactical offensive actions and greater efficiency in the offensive actions and the development of the game [9,14]. The variables of interaction and proximity between the players, associated with the dimensions of the field, influence the number of shots and passes [16]. These modifications also affect specific actions done by the players with the ball, such as dribbling [17]. As far as the size of the goal is concerned, a bigger goal involves a higher number of shots on goal [10], and a smaller goal involves a higher number of interventions by the goalkeeper [18].

The use of a competition format not adapted to the characteristics of players could have a negative impact on their training process and their LTAD [19,20]. The low number of experimental studies makes it difficult to assess the real effect of the regulatory changes and which is the most suitable competition format for each age-group for LTAD in football. The information currently available shows that a reduction in the number of players, the pitch, and the size of the goals compared to the normative competition could result in an improvement in the technical–tactical parameters at a qualitative and quantitative level [9,10,13,14]. Given that most common regulatory competitions in Spain are of the football-8 and football-7 formats, with a playing area of 171.42 m^2 and 150 m^2, respectively, per player, and with goals measuring 6×2 m, a smaller format could contribute to the development of competitions that allow for a better development of youth football players according to their maturity and sport skills. Knowing the incidence of these rule changes will allow different stakeholders to adapt the game to the youth football players. The objective of this study was to analyse the effect of a reduction in the number of players (from 8 vs. 8 to 5 vs. 5), the size of the goal (from 6×2 m to 3×2 m) and the playing space (from 58×38 m to 38×20 m), on the technical and tactical actions in youth football players.

2. Materials and Methods

2.1. Design

A quasi-experimental A-B-A design was implemented to assess the effect of the rule changes. The design conditions moved from official rules (situation A, no changes in the rules), change in the official rules (situation B, modified rules), and official rules (situation A). The A-B-A type design is characterized by two control phases that give the study a higher degree of internal validity than the classic A-B type designs [21]. The players studied played the tournaments with their own teams.

2.2. Participants

The sample consisted of 40 male under-12 football players belonging to four amateur male teams (10 players per team) of the U-12 age group. The characteristics of the players were the following: average age (11.73 ± 0.43 years); training sessions per week (2.50 ± 0.57 sessions); session time (1.37 ± 0.44 h); hours of training per week (3.27 ± 0.65 h), and years of experience (2.93 ± 1.15 years). The guardians of the players were informed of the study and provided written consent. The players played three tournaments using two competition formats (official rules, modified rules, and official rules) and using a pre-established system of substitutions. A total of 8697 ball possession actions taken by the players in 24 matches were analysed. The study was approved by the University Ethics Committee of the principal authors with ID 1944/2018.

2.3. Variables

The independent variable was the game format. There were two levels: official rules and modified rules. The differences between the official and modified rules were the following: size of the field (58 × 38 m vs. 38 × 20 m), number of players per team (8 per team vs. 5 per team), and goal size (6 × 2 m vs. 3 × 2 m). Table 1 shows the rules that were used in both competition formats. The first and third tournaments were played according to the official state rules for U-12 competitions established by the football federation (football-8). In the second tournament, the modification of the official U-12 football rules (football-5) was applied.

Table 1. Description of the rules implemented in the tournaments (football-8 and football-5).

Rules	Official Rules (Football-8)	Modified Rules (Football-5)
Number of players	7 outfield players + 1 goalkeeper	4 outfield players + 1 goalkeeper
Number of players (team)	15	7
Field size (m)	58 × 38 m	38 × 20 m
Goal size (m)	6 × 2 m	3 × 2 m
Penalty area size (m)	24 × 9 m	12 × 6 m
Goal area size (m)	12 × 3 m	None used
Ratio of m^2 per field player	314 m^2	190 m^2
m^2 of the goal	12 m^2	6 m^2
Ball size (n)	4	4
Substitutions	Unlimited	Unlimited
Time (minutes)	2 × 20	2 × 20

The dependent variables were: the technical–tactical actions by which the player obtained the ball (steal, clearance from a player, rebound, pass interception, set-piece kick, teammate pass, pass after throw-in, pass after set piece, and throw-in); actions done when the team has ball possession (basic collective tactical actions, dribbles, number of contacts when driving, and type of dribble); and actions which end teams' ball possession (throw-in pass, shot off target, shot stopped by the goalkeeper, ball lost, clearance from a player, out of bounds, and other actions); the ball height in which the possession starts and ends; the body surface used to start and end the possession; distance from nearest opponent; teammates supporting; pressure lines surpassed with ball; and field area. The variables registered are part of the observation instrument (observation instrument for technical and tactical actions of the offence phase in soccer) that was designed and validated by Ortega-Toro, García-Angulo, Giménez-Egido, García-Angulo, and Palao [22].

2.4. Procedure

The data were recorded in three tournaments that were played in a period of three weeks (one week between tournaments). The tournaments were played after the end of the official regular season and on weekends. All tournaments were played at the same time of day and in similar weather conditions. In total, 24 matches were played in the three tournaments (six matches in the first tournament; 12 matches in the second tournament; and six matches in the third tournament). The competition system was round robin. The order of the confrontations was the same in the different tournaments. Before the tournaments, a pre-established system of substitutions was determined, in order to establish an equitable distribution of minutes per player (1st tournament: 25.45 ± 1.45; 2nd tournament: 32.00 ± 2.48; and 3rd tournament: 25.45 ± 1.45). In the second tournament (situation B, modified rules), each team played the same number of matches as in the first and third tournaments, but each team was divided into two sub-teams. This allowed for the playing of two simultaneous matches on adjacent soccer fields, with two 20-min periods, played on a 38 × 20 m soccer field, with five players plus one outfield player for substitutions, and two goals on each 38 × 20 m field. After the first game between sub-teams, the other sub-teams' match was played. The result of the matches was calculated from the overall goals scored in both matches. In all the tournaments, a 10-min half-time period was established between each period of the same match. Once a match was finished, five minutes were established to start the next match.

The actions developed by the players were recorded with two fixed digital cameras from an elevated rear view. The actions were recorded and analysed by two trained observers (with a Masters degree in Sports Science and at least 5 years of experience in match analysis and soccer). The observers were trained with the observation instrument before beginning the study. After the training period, the inter- and intra-observer reliability were calculated. To calculate the intra-observer reliability, another researcher was used as a reference. The researcher held a sports science degree and had more than ten years of experience in sports analytics. The reliability of the observers was measured before and after the observation. The lowest level of interobserver reliability was 0.83, and the lowest level of intra-observer reliability was 0.92 (Kappa index).

2.5. Data Analysis

Descriptive (means and standard deviation) and inferential statistics of the data were calculated. To measure the difference between different tournaments, an analysis of variance for repeated measures was calculated. Mauchly's test of sphericity and Pillai's trace were used. Bonferroni post hoc analysis was used. The level of significance was set at $p < 0.05$. To measure the magnitude of the effect size, the eta square (η^2) was used, using the following classification [23]: no effect ($\eta^2 < 0.04$), minimum effect ($0.04 < \eta^2 < 0.25$), moderate effect ($0.25 < \eta^2 < 0.64$) and strong effect ($\eta^2 > 0.64$). The statistical analysis was completed with SPSS software (version 24.0, IBM, Chicago, IL, USA).

3. Results

Regarding the way players obtained the ball (Table 2), the results show statistically significant differences between tournaments in obtaining the ball after a clearance from a player ($F_{2,6} = 8.610$, $p = 0.001$, $\eta^2 = 0.330$). Statistically significant differences were observed between Tournament 1 and Tournament 2 ($p = 0.001$). There were no significant differences between Tournaments 1 and 3 ($p = 0.229$) or between Tournaments 2 and 3 ($p = 0.100$). The effect size on this variable was moderate. Significant differences were found when the ball was obtained by intercepting a pass ($F_{2,6} = 7.330$, $p = 0.002$, $\eta^2 = 0.295$), between Tournament 1 and Tournament 2 ($p = 0.001$). These differences had a moderate effect size. Statistically significant differences were found in the number of balls obtained by a pass from a teammate. There was a significantly higher number of passes in Tournament 2 ($F_{2,6} = 8.961$, $p = 0.001$, $\eta^2 = 0.339$). A post hoc analysis shows differences between Tournament 1 and Tournament 2 ($p < 0.001$). Tendencies toward significance were found between Tournament 2 and Tournament 3 ($p = 0.061$), and no differences were found between Tournament 1 and Tournament 3 ($p = 0.486$). These differences had a moderate effect size. Significant differences were found regarding throw-ins ($F_{2,35} = 16.428$, $p < 0.001$, $\eta^2 = 0.484$) and after a throw-in ($F_{2,6} = 9.043$, $p = 0.001$, $\eta^2 = 0.341$). Tournament 2 had significantly higher values than Tournament 1 for both variables ($p < 0.001$). These differences had a moderate effect size for both variables.

Table 2. Technical-tactical actions through which the ball is received.

Player Action	Tournament 1 Football 8	Tournament 2 Football 5	Tournament 3 Football 8	Significance Post Hoc	Effect Size (η^2)
Steal	5.84 ± 4.54	6.57 ± 6.09	6.14 ± 3.83	n.s.	0.054
Clearance	10.08 ± 5.40	14.14 ± 8.93	11.57 ± 5.76	T1 < T2 = T3	0.330
Rebound	1.46 ± 1.75	2.16 ± 2.19	1.57 ± 1.60	n.s.	0.119
Pass interception	10.54 ± 10.24	14.92 ± 11.68	12.19 ± 10.14	T1 < T2 = T3	0.295
Set-piece kick	3.84 ± 3.78	5.05 ± 4.15	3.86 ± 3.38	n.s.	0.109
Teammate Pass	20.76 ± 14.38	28.54 ± 20.20	24.78 ± 14.26	T1 < T2 = T3	0.339
Pass after throw-in	2.65 ± 2.77	4.84 ± 3.68	3.32 ± 2.79	T1 < T2 = T3	0.341
Pass after set piece	3.62 ± 3.41	4.30 ± 3.54	3.16 ± 2.91	n.s.	0.145
Throw-in	4.68 ± 8.08	9.62 ± 7.74	6.68 ± 11.23	T1 < T2 = T3	0.484

Legend: T1 = Tournament 1 (8 a-side); T2 = Tournament 2 (5 a-side); T3 = Tournament 3 (8 a-side); n.s. = no significant differences.

Related to the way that the ball was obtained (Table 3), statistically significant differences were found for all the heights at which the ball is obtained: ground level ($F_{2,35} = 6.260$, $p = 0.005$, $\eta^2 = 0.263$), middle-height ball ($F_{2,35} = 6.986$, $p = 0.003$, $\eta^2 = 0.285$), and a high ball ($F_{2,35} = 13.900$, $p < 0.001$, $\eta^2 = 0.443$). Tournament 2 had significantly higher occurrence of high balls than Tournament 1 and Tournament 3. These differences had a moderate effect size. Statistically significant differences were found in obtaining the ball with the foot ($F_{2,35} = 10.888$, $p < 0.001$, $\eta^2 = 0.384$), with the hand ($F_{2,35} = 7.079$, $p = 0.003$, $\eta^2 = 0.288$), and with the head ($F_{2,35} = 13.382$, $p < 0.001$, $\eta^2 = 0.433$). Tournament 2 had a higher occurrence than Tournament 1 ($p < 0.003$) and Tournament 3 ($p = 0.010$). These differences had a moderate effect size. Statistical differences were found in the variable very close distance from the nearest opponent ($F_{2,35} = 7.052$, $p = 0.003$, $\eta^2 = 0.287$), in close distance ($F_{2,35} = 5.844$, $p = 0.006$, $\eta^2 = 0.250$), in near distance ($F_{2,35} = 6.843$, $p = 0.003$, $\eta^2 = 0.281$), and in distant distance ($F_{2,35} = 36.315$, $p < 0.001$, $\eta^2 = 0.675$). Tournament 2 had a higher occurrence of near and far away distances than Tournament 1 and Tournament 3. The effect size of this variable was moderate for the very close, close, and near distances and was strong for the far away distance. Statistical differences were found in the situation where a teammate was supporting the player with the ball between the tournaments ($F_{2,35} = 13.985$, $p < 0.001$, $\eta^2 = 0.444$). Tournament 2 had a higher occurrence than Tournament 1 ($p < 0.001$) and Tournaments 3 ($p = 0.044$). The effect size of this variable was moderate.

Table 3. Technical–tactical aspects in the obtaining of the ball.

Variable	Categories	Tournament 1 Football 8	Tournament 2 Football 5	Tournament 3 Football 8	Significance Post Hoc	Effect Size (η^2)
Ball height	At ground level	32.73 ± 20.39	42.11 ± 30.96	36.97 ± 19.57	T1 < T2 = T3	0.263
	Middle ball	9.35 ± 5.86	11.92 ± 7.57	10.81 ± 4.80	T1 < T2 = T3	0.285
	High ball	11.00 ± 6.22	18.59 ± 11.16	13.38 ± 6.86	T1 < T2 > T3	0.443
Part obtaining the ball	Foot	49.22 ± 28.94	66.68 ± 41.52	56.78 ± 26.73	T1 < T2 = T3	0.384
	Hand	5.49 ± 8.48	9.86 ± 7.82	7.78 ± 11.17	T1 < T2 = T3	0.288
	Head	5.08 ± 4.65	9.65 ± 7.08	6.54 ± 5.47	T1 < T2 > T3	0.433
	Other	1.76 ± 1.99	3.27 ± 3.05	2.16 ± 1.80	T1 < T2 = T3	0.263
Distance from nearest opponent	Very close	16.41 ± 8.78	22.62 ± 16.71	19.92 ± 10.12	T1 < T2 = T3	0.287
	Close	13.68 ± 8.83	17.32 ± 12.33	15.92 ± 9.20	T1 < T2 = T3	0.250
	Near	10.70 ± 6.62	14.51 ± 8.40	11.03 ± 5.38	T1 < T2 > T3	0.281
	Far away	19.65 ± 13.16	37.08 ± 23.19	26.41 ± 19.87	T1 < T2 > T3	0.675
Teammates supporting	Yes	24.89 ± 15.57	38.19 ± 25.63	30.41 ± 19.81	T1 < T2 > T3	0.444

Legend: T1 = Tournament 1 (Football 8); T2 = Tournament 2 (Football 5); T3 = Tournament 3 (Football 8).

Figure 1 shows the zones in which the player obtained possession of the ball. Statistically significant differences were found in the left initiation zones ($F_{2,35} = 17.691$, $p < 0.001$, $\eta^2 = 0.503$). Tournament 2 had a higher occurrence for this than Tournament 1 ($p < 0.001$) and Tournament 3

($p < 0.001$). The effect size of this variable was moderate. In the central zone ($F_{2,35} = 8.875$, $p = 0.001$, $\eta^2 = 0.336$), Tournament 2 had a higher occurrence than Tournament 1 ($p = 0.001$). The effect size of this variable was moderate. In the right initiation zone ($F_{2,35} = 6.967$, $p = 0.003$, $\eta^2 = 0.285$), Tournament 2 had a higher occurrence than Tournament 1 ($p = 0.002$) or Tournament 3 ($p = 0.011$). The effect size of this variable was moderate. Statistically significant differences were found in the left creation–finalization zone ($F_{2,35} = 3.968$, $p = 0.028$, $\eta^2 = 0.185$). Tournament 1 had a higher occurrence for this than Tournament 2 ($p = 0.025$). The effect size of this variable was minimal. Statistically significant differences were found in the central finishing zone ($F_{2,35} = 3.337$, $p = 0.047$, $\eta^2 = 0.160$). Tournament 1 had a higher occurrence for this than Tournament 2 ($p = 0.045$). These differences had a moderate effect size.

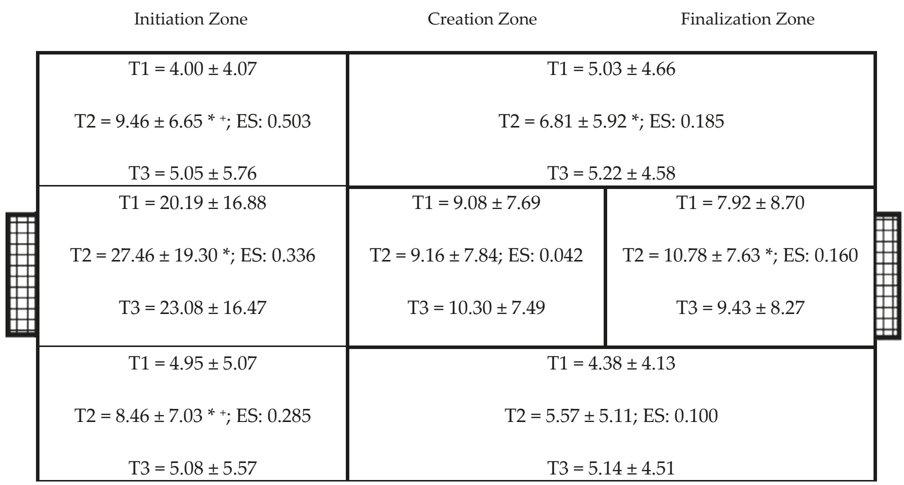

Figure 1. Zones where the player receives the ball. Legend: * Statistically significant differences between Tournament 1 (T1) and Tournament 3 (T3); + Statistically significant differences between Tournament 2 (T2) and Tournament 3 (T3); ES: effect size (η^2).

Regarding the actions performed by the players with the ball (Table 4), statistically significant differences in the use of basic collective tactical actions were found ($F_{2,6} = 12.022$, $p < 0.001$, $\eta^2 = 0.414$.). Tournament 2 had a significantly higher occurrence of the non-use of collective tactical actions than Tournaments 1 and 3 ($p < 0.001$). Tournament 2 had a significantly higher occurrence of the use of the wall than Tournament 3 ($p = 0.002$). In both variables, these differences had a moderate effect size. Significant differences were found in other collective tactical actions ($F_{2,34} = 11.770$, $p < 0.001$, $\eta^2 = 0.409$). Tournament 2 had a higher use of penetration actions than Tournament 1 ($p < 0.001$) and Tournament 3 ($p < 0.001$). The effect size was moderate. The use of no dribbling was statistically significant and higher in Tournament 2 than in Tournaments 1 and 3 ($F_{2,6} = 16.352$, $p < 0.001$, $\eta^2 = 0.483$). These differences had a moderate effect size. In the analysis of the number of contacts whilst dribbling the ball, the results show differences in the number of actions that occur without dribbling ($F_{2,35} = 12.069$, $p < 0.001$, $\eta^2 = 0.408$) and while dribbling the ball with two contacts ($F_{2,35} = 6.547$, $p = 0.004$, $\eta^2 = 0.272$). Tournament 2 had a significantly higher occurrence than Tournament 1 ($p = 0.009$) and 3 ($p = 0.009$, no dribbling). In both variables, the effect size was moderate. The results with regard to the type of dribbling show differences in actions, in which players did not dribble the ball ($F_{2,35} = 11.973$, $p < 0.001$, $\eta^2 = 0.406$). Tournament 2 had a higher occurrence than Tournaments 1 ($p < 0.001$) and 3 ($p = 0.040$). Tournament 3 had a higher occurrence than Tournament 1 ($p = 0.023$). The size effect was moderate. Tournament 2 had a significantly higher use of the timing actions than Tournament 1 ($F_{2,35} = 7.858$, $p = 0.002$, $\eta^2 = 0.310$). Significant differences were found in the use of penetration actions

($F_{2,35}$ = 25.550, $p < 0.001$, $\eta^2 = 0.593$). Tournament 2 had a significantly higher use of penetration actions than Tournament 1 ($p < 0.001$) and Tournament 3 ($p < 0.001$). Tournament 3 had a significantly higher use of penetration actions than Tournament 1 ($p = 0.028$). In both, the effect size was moderate. The actions in which no pass lines were surpassed were significantly higher in Tournament 2 than in Tournament 1 ($F_{2,35}$ = 43.545, $p < 0.001$, $\eta^2 = 0.713$). The effect size was strong. The actions in which a player passed one defensive line with a pass were significantly higher in Tournament 2 than in Tournament 1 ($F_{2,35} = 5.243^{a}$, $p = 0.010$, $\eta^2 = 0.231$). The effect size was moderate.

Table 4. Tactical aspects performed by the player with the ball in the development of the action.

Variable	Categories	Tournament 1 Football 8	Tournament 2 Football 5	Tournament 3 Football 8	Signific. Post Hoc	Effect Size (η^2)
Collective tactical actions	No tactical actions	63.14 ± 33.97	88.83 ± 53.53	72.64 ± 35.71	T1 < T2 > T3	0.414
	Wall pass	1.58 ± 2.13	2.00 ± 3.08	0.061 ± 1.10	T1 = T2 > T3	0.314
	Others	0.25 ± 0.73	1.39 ± 1.53	0.11 ± 0.31	T1 < T2 > T3	0.409
Dribbles	No dribbling	50.89 ± 27.26	76.24 ± 43.72	60.32 ± 30.48	T1 < T2 > T3	0.483
	One	8.84 ± 7.49	10.70 ± 9.52	8.86 ± 6.43	n.s.	0.105
	≥2	4.35 ± 4.88	4.89 ± 5.35	4.08 ± 3.51	n.s.	0.054
Number of contacts in driving	No contacts	40.59 ± 23.59	58.22 ± 34.44	47.95 ± 26.77	T1 < T2 > T3	0.408
	2 contacts	13.92 ± 8.34	18.32 ± 12.95	16.22 ± 9.67	T1 < T2 = T3	0.272
	3–4 contacts	5.70 ± 5.75	7.22 ± 6.70	6.97 ± 5.96	n.s.	0.142
Type of dribble	There is no dribbling	40.19 ± 23.38	57.43 ± 33.50	47.81 ± 26.73	T1 < T2 > T3	0.406
	Timing	13.86 ± 8.41	19.68 ± 14.28	16.32 ± 9.69	T1 < T2 = T3	0.310
	Counterattack	9.65 ± 9.91	10.43 ±1 0.75	9.03 ± 7.36	n.s.	0.048
	Penetration	0.30 ± 0.66	4.30 ± 3.62	0.08 ± 0.27	T1 < T2 > T3	0.593
Pressure lines passed with ball	No pass line	33.59 ± 19.03	64.22 ± 32.78	48.05 ± 25.10	T1 < T2 > T3	0.713
	One line	19.54 ± 17.90	23.89 ± 22.75	22.49 ± 14.86	T1 <T 2 = T3	0.231
	More than one line	3.54 ± 3.83	3.73 ± 4.24	2.73 ± 2.21	n.s.	0.081

Legend: T1 = Tournament 1 (football-8); T2 = Tournament 2 (football-5); T3 = Tournament 3 (football-8); BCTAs: Basic collective tactical actions; n.s. = no significant differences.

Regarding the way the ball possession ends (Table 5), significant differences between tournaments were found in the actions of losing the possession with a pass to a teammate ($F_{2,35}$ = 12.578, $p < 0.001$, $\eta^2 = 0.418$). Tournament 2 had a significantly higher occurrence than Tournament 1 ($p = 0.001$). Tournament 3 had a significantly higher occurrence than Tournament 1 ($p = 0.002$). The effect size of this variable was moderate. Significant differences between tournaments were found in the number of shots stopped by the goalkeeper ($F_{2,35}$ = 16.552, $p < 0.001$, $\eta^2 = 0.486$). Tournament 2 had a significantly higher occurrence than Tournament 1 (p <.001) and Tournament 3 ($p = 0.001$). The effect size of this variable was moderate. There were differences between tournaments in the number of balls lost ($F_{2,35}$ = 4.017, $p = 0.027$, $\eta^2 = 0.187$). Tournament 2 had a significantly higher occurrence than Tournament 1 ($p = 0.027$) and Tournament 3 ($p = 0.026$). The effect size of this variable was minimal. Significant differences between tournaments were found in the number of clearances ($F_{2,35}$ = 17.687, $p < 0.001$, $\eta^2 = 0.503$). Tournament 2 had a significantly higher occurrence than Tournament 1 ($p < 0.001$) and Tournament 3 ($p = 0.013$). The effect size of this variable was moderate. Significant differences between tournaments were found in out of bounds ($F_{2,35} = 7.755^{a}$, $p = 0.002$, $\eta^2 = 0.307$). Tournament 2 had a significantly higher occurrence than Tournament 1 ($p < 0.004$) and Tournament 3 ($p = 0.001$). The effect size was moderate. Significant differences between tournaments were found in other actions ($F_{2,35} = 6.728^{a}$, $p = 0.003$, $\eta^2 = 0.278$). Tournament 2 had a significantly higher occurrence than Tournament 1 ($p < 0.002$). The effect size was moderate.

Table 5. Technical-tactical actions by which players end ball possession.

Player Action	Tournament 1 Football 8	Tournament 2 Football 5	Tournament 3 Football 8	Significance Post Hoc	Effect Size (η^2)
Pass to teammate	20.03 ± 14.27	26.65 ± 20.75	27.97 ± 15.79	T1 < T2 = T3	0.418
Lost pass	0.73 ± 1.40	0.89 ± 1.62	0.54 ± 0.93	n.s	0.075
Throw-in pass	1.62 ± 2.60	4.70 ± 3.82	1.32 ± 1.70	T1 < T2 > T3	0.569
Shot off target	3.38 ± 3.36	4.43 ± 3.49	3.24 ± 2.76	n.s.	0.144
Shot stopped by the goalkeeper	2.95 ± 3.13	6.73 ± 4.81	3.65 ± 3.22	T1 < T2 > T3	0.486
Ball lost	12.08 ± 7.92	16.24 ± 13.44	11.57 ± 7.48	T1 < T2 > T3	0.187
Clearance from a player	15.08 ± 12.03	22.95 ± 13.32	18.81 ± 14.57	T1 < T2 > T3	0.503
Out of bounds	2.68 ± 2.00	4.54 ± 3.71	2.43 ± 2.15	T1 < T2 > T3	0.307
Other action	2.86 ± 2.69	4.65 ± 3.90	3.49 ±2.99	T1 < T2 = T3	0.278

Legend: T1 = Tournament 1 (8 a side); T2 = Tournament 2 (5 a side); T3 = Tournament 3 (8 a side); n.s. = no significant differences.

Related to the zones in which the possession of the ball ends (Figure 2), statistically significant differences were found in the left initiation zone ($F_{2,35} = 15.449$, $p < 0.001$, $\eta^2 = 0.469$). Tournament 2 had a significantly higher occurrence than Tournament 1 and Tournament 3 ($p < 0.001$). Statistically significant differences were found in the central initiation zone ($F_{2,35} = 7.450$, $p = 0.002$, $\eta^2 = 0.299$). Tournament 2 had a significantly higher occurrence than Tournament 1 ($p = 0.002$). Statistically significant differences were found in the right initiation zone ($F_{2,35} = 9.279$, $p = 0.001$, $\eta^2 = 0.346$). Tournament 2 had a significantly higher occurrence than Tournament 1 ($p < 0.001$) and Tournament 3 ($p < 0.002$). The effect size of these three variables was moderate. A trend towards significance was found in the central end zone ($F_{2,35} = 3.164$, $p = 0.055$, $\eta^2 = 0.153$). Tournament 2 had a more significant tendency to have a higher occurrence than Tournament 1 ($p = 0.059$). The effect size of these three variables was minimal.

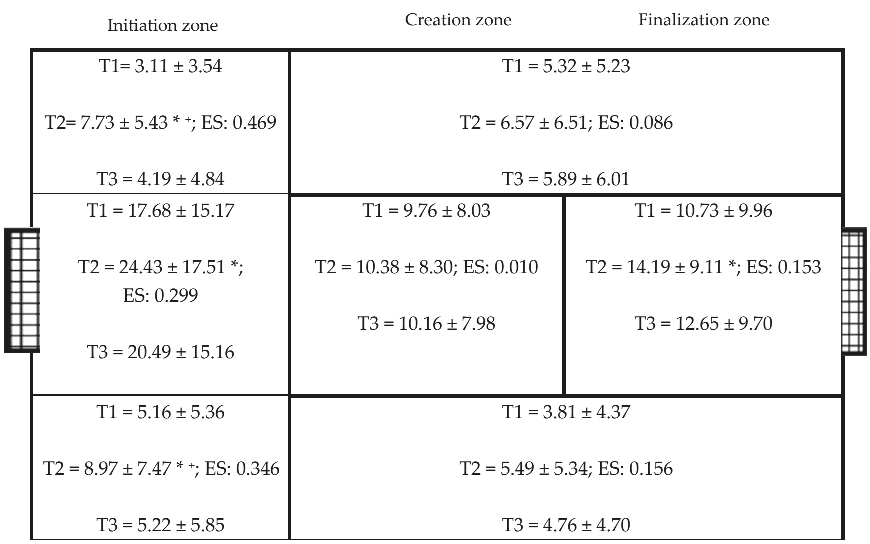

Figure 2. Zone where possession ends * Statistically significant differences between T1 and T3. + Statistically significant differences between T2 and T3. ES: effect size (η^2).

Regarding the characteristics of the technical–tactical actions in which the player lost possession of the ball (Table 6), statistically significant differences were found in the middle ball height ($F_{2,35} = 35.226$, $p < 0.001$, $\eta^2 = 0.668$), and in high balls ($F_{2,35} = 11.602$, $p < 0.001$, $\eta^2 = 0.399$). Tournament 2 had a higher occurrence than Tournament 1 and Tournament 3 ($p < 0.001$). The effect sizes of these three variables were strong and moderate, respectively. A significantly higher number of actions ended with the foot ($F_{2,35}$ = 9.459, p = 0.001, η^2 = 0.351), with the hands ($F_{2,35}$ = 13.470, p < 0.001, η^2 = 0.435), and with the head ($F_{2,35}$ = 14,622, p < 0.001, η^2 = 0.455). Tournament 2 had a significantly higher occurrence than Tournament 1 (p < 0.001). In the actions that ended with the head, Tournament 2 had a significant higher occurrence than Tournament 3 (p < 0.001). The effect size of these three variables was moderate. Statistically significant differences were found in the actions that ended at a very close distance to the opponent ($F_{2,35}$ = 6.503, p = 0.004, η^2 = 0.27), and at close distance ($F_{2,35}$ = 13.409, p < 0.001, η^2 = 0.434). Tournament 2 had a significantly higher occurrence than Tournament 1 (p < 0.001). In the actions that ended at a very close distance to the opponent, Tournament 2 had a significantly higher occurrence than Tournament 1 (p < 0.003) and Tournament 3 (p < 0.042). The effect size was moderate in both variables. Statistically significant differences were found in the presence of a supporting partner between tournaments ($F_{2,35}$ = 10.383, p < 0.001, η^2 = 0.372). Tournament 2 had a significantly higher occurrence than Tournament 1 (p < 0.001) and 3 (p = 0.042). The effect size was moderate. Statistically significant differences were found in situations in which a pressure line was not surpassed ($F_{2,35}$ = 10.938, p < 0.001, η^2 = 0.385) and in situations in which the pressure line was surpassed ($F_{2,35}$ = 13.078, p < 0.001, η^2 = 0.428). Tournament 2 had a significantly higher occurrence than Tournament 1 (p < 0.001) and 3 (p < 0.004). The effect size was moderate.

Table 6. Technical–tactical aspects in the finalization of the possession of the ball.

Variable	Categories	Tournament 1 Football 8	Tournament 2 Football 5	Tournament 3 Football 8	Significance Post Hoc	Effect Size (η^2)
Ball height	At ground level	30.89 ± 20.27	30.38 ± 23.59	35.62 ± 19.18	n.s.	0.112
	Middle ball	8.78 ± 5.01	23.32 ± 13.81	10.27 ± 5.26	T1 < T2 > T3	0.668
	High ball	24.38 ± 17.40	38.08 ± 23.80	27.35 ± 20.51	T1 < T2 > T3	0.399
Final body part in contact with the ball	Foot	50.68 ± 27.03	67.95 ± 41.53	58.97 ± 27.36	T1 < T2 = T3	0.351
	Hand	5.49 ± 8.11	9.84 ± 7.50	7.32 ± 11.01	T1 < T2 = T3	0.435
	Head	7.03 ± 5.21	12.59 ± 8.53	6.35 ± 4.68	T1 < T2 > T3	0.455
	Other	0.84 ± 1.16	1.46 ± 1.64	0.62 ± 0.75	T1 < T2 > T3	0.260
Distance from nearest opponent	Very close	25.81 ± 15.79	34.70 ± 24.44	27.46 ± 14.44	T1 < T2 > T3	0.271
	Close	14.51 ± 7.82	20.95 ± 12.40	18.24 ± 7.96	T1 < T2 = T3	0.434
	Near	11.11 ± 8.68	12.16 ± 9.24	9.62 ± 7.28	n.s.	0.133
	Far away	12.19 ± 11.40	24.03 ± 15.14	17.86 ± 16.75	T1 < T2 > T3	0.538
Teammates supporting	Yes	26.92 ± 17.67	38.59 ± 27.72	30.27 ± 16.26	T1 < T2 > T3	0.372
Pressure lines surpassed with ball	No pass line	38.57 ± 20.20	54.22 ± 30.69	47.19 ± 23.88	T1 < T2 = T3	0.385
	One line	22.00 ± 15.09	33.46 ± 24.79	23.27 ± 13.59	T1 < T2 > T3	0.428
	More than one line	3.57 ± 5.28	3.86 ± 3.83	2.78 ± 3.02	n.s.	0.128

Legend: T1 = Tournament 1 (8 a side); T2 = Tournament 2 (5 a side); T3 = Tournament 3 (8 a side); n.s. = no significant differences.

4. Discussion

The objective of this study was to analyse the effect of a reduction in the number of players, the size of the goal, and the playing space on the technical and tactical actions in youth male football players. An experimental tournament was carried out to test the implication of these rule changes on U-12 players. The changes in field and goal size and number of players resulted in an increase in the individual and collective actions done by the players. The experimental rules involved greater variability in the type of actions done by players related to the contact height, the contact surface, and the distance of the opponent. The rule changes led to a higher number of passes and actions when a teammate supported the player with the ball. These increments could be due to the increase in the players per square meter, which reduced the possibilities to progress by dribbling the ball, which were higher under the official rules. The experimental rules involved a higher use of the lateral zones of the field, and a higher number of shots, passes, and interceptions. This combination, more passes, and the use of more areas of the field created more space on defence, a higher number of offensive actions, and higher collective participation in the experimental format. From the perspective of the players' experience, the proposed rules involved higher participation and higher variability. This could help to improve tactical thinking and the ability to try different solutions for game problems, etc. [24]. The results confirm the findings of previous observational studies that showed a higher occurrence and variability of defensive actions, passes, and ball actions when there was a reduction in the field size and the number of players in U-8 [14], U-12 [9], and U-14 [13,25]. The use of the adapted rules format increased the number and variability of the players' actions [13,25], which could involve a richer experience for the players.

The findings related to collective participation confirm previous observational studies in competition and training. A reduction in the field size and the number of players involved a higher number of offensive actions and their efficacy [9,10,13,26,27]. The reduction in the goal size increases goalkeeper participation due to a higher number of offensive actions [18]. Experimental studies in small-side games also found that the manipulation of the space and number of players are critical structural factors that affect the technical, tactical and physical actions of the players [11,28]. To our knowledge, this is the first experimental study that analyses the effect of these manipulations on the technical–tactical actions on competition. This type of study is critical to understand the impact of the rules format on the LTAD of youth football players. The competition is the reference of the process and involves critical experiences that affect player development. The competition rules are like the curriculum used in physical education to guide the process in order to achieve the desired competencies and skills. The rules format should be adapted to the maturity and skills of players, and it should provide a progressive, challenging, and achievable environment through the different stages of player development. However, in different age-groups, the adaptation of the formal rules reduces the participation and the variability and involves less efficacy in their actions; This may be due to the fact that the rules do not create technical–tactical situations appropriate for this age group [14]. These ideas have been proposed by previous observational studies done in different age groups [9,13,25].

The experimental rules tested promote the realization of passes, supporting the teammates, a higher number of actions close to the goals, a higher number of actions in defence and offence, and the use of the different zones of the field versus the format rules that promote the use of individual actions (e.g., dribbling) to a greater extent. This experimental format better fits players' individual progression (U-12) and players' and teams' collective development. It could allow players to evolve from the individuality of previous stages, based on dribbling and side steps. With the experimental rules, there are fewer times that players dribble through the defensive lines, but more times that players pass through the defensive lines. The pass is a critical element for the tactical development of players and teams [29–31]. The experimental rules increase the use of the pass as a collective solution to the problems that come up in a game [32]. The use of different zones of the field introduces the concepts of generating space and centres in the game. These also allow one to introduce more complex tactical systems. The findings from this study and previous studies [9,10,18] show how a reduction in the field and goal size and the number of players in under-12 football provided a more appropriate experience for the players studied, due to the higher participation of the outfield players and goalkeepers, higher variability, and greater efficacy of their individual actions, and for the type of collective actions done.

The findings of the current study must be interpreted with caution. The study only analysed the short-term effects of the experimental rules. The medium- and long-term impact of training and competing with the experimental format is unknown. Future studies should analyse the impact of the rule modifications after a period of training. At this level, it must be considered that the use of the experimental format involves a reduction in the number of players per team, which could indirectly affect the players that play and the competition format. A possible solution to this problem could be to sub-divide the teams into two and play simultaneously on the reduced-sized field [33]. The study had a reduced sample, only male, and with specific sports skills (formative team). No teams from the elite U-12 teams of the region/zone were studied. This may influence the level of physical/biological development of the players, their skills, and their level of specialization. The findings show how the experimental rules allowed players to carry out more passes, have more variability in the way the actions are executed, and use different zones. This result can show the need to develop these skills in practice to continue their development (e.g., creating openings, wider use of the field, variability in the task, etc.). The study only analysed the technical and tactical actions of the players, and it did not analyse the physical actions, psychological variables, injuries, etc. Despite the limitations and delimitations, the findings show that the structural manipulation of the field and goal size and the number of players provided higher participation, variability, and tactical actions that could involve a better LTAD for the players studied. The current study is one of the first experimental steps in the study of rules formats and their impact on the LTAD of youth football players. Future studies should analyse the effect of the different rule formats in each age group, their synchronization, progression, and their relationship with the LTAD from a holistic perspective.

5. Conclusions

The experimental rules, namely the reduction in the number of players, field size, and goal size, promoted the realization of more actions and more variability in these actions. There was a significant increase in the passes that passed through defensive lines and a greater number of actions in the offensive zone. The experimental format better fits the players' individual progression (U-12) and players' and teams' collective development, and it will allow the players to evolve from the individual development of previous stages. The rules of youth sport play a critical role in a player's LTAD. Future studies are necessary to establish the proper rules for each age group to facilitate their appropriate development.

Author Contributions: Conceptualization, A.G.-A., E.O.-T., J.M.G.-E., F.J.G.-A. and J.M.P.; Data curation, E.O.-T., J.M.G.-E. and F.J.G.-A.; Formal analysis, E.O.-T. and J.M.P.; Investigation, A.G.-A., E.O.-T., J.M.G.-E., F.J.G.-A., and J.M.P.; Methodology, A.G.-A., E.O.-T., J.M.G.-E., F.J.G.-A. and J.M.P.; Software, E.O.-T. and J.M.P.; Supervision, A.G.-A., E.O.-T. and J.M.P.; Visualization, A.G.-A., E.O.-T., J.M.G.-E., F.J.G.-A. and J.M.P.; Writing—original draft preparation, A.G.-A., E.O.-T. and J.M.P.; Writing—review and editing, A.G.-A., E.O.-T. and J.M.P.; Funding acquisition: E.O.-T. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Ministry of Science and Innovation, Spain, under Grant DEP2010-16140. Project "Salvador de Madariaga", of the Ministry of Education, culture and sport (PRX16 / 00422). Murcia Regional Football Association's (Spain), Football Proyect, under Grant FFRM-UMU-04 0092 321B 64502 14704. And Ministry of Economy, Industry and Competitiveness, under Grant DEP2017-90641-REDT.

Conflicts of Interest: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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International Journal of
Environmental Research and Public Health

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Article

Validation of the Scale of Basic Psychological Needs towards Physical Exercise, with the Inclusion of Novelty

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Received: 29 December 2019; Accepted: 16 January 2020; Published: 18 January 2020

Abstract: The purpose of this study was to validate and adapt to the Spanish context of Physical Education, the Spanish version of the Scale of Basic Psychological Needs in the context of physical exercise, with the incorporation of novelty to the scale. The sample that took part in the study was 2372 people from 16 to 48 years old from the province of Almeria. In order to analyze the psychometric properties of the scale, several analyses have been carried out. The results have offered support both for the eight-factor structure and for the higher-order double model where the eight subscales are joined into two constructs called frustration and satisfaction. The structure of both models was invariant with respect to gender and age. Cronbach's alpha values were above 0.70 in the subscales and scales; and adequate levels of temporal stability. In addition, the subfactors pertaining to the satisfaction of basic psychological needs positively predicted the intrinsic motivation for physical activity, while each of the subfactors of the frustration of psychological needs predicted it negatively. The results of this study provide evidence of the reliability and validity of the BPNS in the Spanish context of physical activity.

Keywords: self-determination theory; intrinsic motivation; basic psychological needs; physical activity

1. Introduction

In recent years, various studies in the field of physical activity and sport have shown the multiple benefits at the physical, cognitive, psychological, emotional, and social levels that are linked to the regular practice of physical activity [1,2]. In this sense, the regular practice of physical activity is linked to the reduction of heart problems, reduction of hypertension, stress, depression, and feelings of loneliness [3]. Despite these benefits, regular physical activity is still very low, with around 61% of the world's population failing to reach the 300 min per week recommended by the World Health Organization [4]. For this reason, several studies have suggested that experiences linked to the practice of physical activity should be positive in order to encourage adherence [5]. Thus, it is especially important to understand both the negative and positive experiences people have had while practicing PA [6,7]. This study aims to adapt and validate to the Spanish context a scale with which to evaluate basic psychological needs in the area of physical exercise, incorporating novelty.

From the Self-Determination Theory (SDT; [8]) it is suggested the existence of a series of psychological needs that are basic and present in all human beings. These needs are necessary for the psychological and social well-being and health of all people, promoting personal growth and development [9]. These basic psychological needs are represented by three essential factors: autonomy, which refers to the fact that people are agents of their own action without external impositions; competence, which refers to having a sense of ability and effectiveness in the action being carried out; and relationship, which refers to the feeling of being integrated into a social group of relevance to the individual [9,10]. However, at present several studies have justified and proposed the incorporation of a fourth basic psychological need called novelty [11,12]. This psychological need refers to the search for new experiences and sensations that have not been experienced or lived before and therefore deviates from the daily routine [13]. This need had previously been mentioned by Deci and Ryan [8] when they defined intrinsic motivation as the active commitment that people acquire with the actions that they find interesting and new and that represent an optimal challenge. This new psychological need is identified with exploration and spontaneous interest, assimilation and improvement as a form of cognitive, emotional and social development [8].

The four basic psychological needs are interrelated, so that if one of them diminishes the others will also diminish [13,14]. Therefore, people who feel influenced when they make decisions, unable when they practice physical activity, excluded from the social reference group, and find the activities monotonous and repetitive, would experience a frustration of their basic psychological needs, which are related to the abandonment of activity, lack of commitment, deficits in interpersonal relationships, and, in short, the manifestation of maladaptive behaviors [15]. Conversely, if people feel autonomous when they make decisions, feel competent when they carry out their activities, accepted and integrated into their social reference group, and the activities turn out to be different and attractive, they will experience a satisfaction of psychological needs, which is related to the learning of new skills, commitment to learning, improvement of interpersonal relations and the manifestation of adaptive behaviours [16].

At present, there are many studies from SDT, especially from the field of Physical Education (PE) classes, which have analyzed the relationship between novelty and the autonomous motivation of students. In this sense, a study carried out by Trigueros, et al. [17] has shown how those students in PE who had high levels of satisfaction of novelty also had high levels of autonomous motivation for PE classes showing that both factors are related. Thus, it is necessary for teachers to promote new and continuous experiences during the PE classes so that their students feel attracted and interested in order to increase the motivation of the students. From the field of physical activity, we have no record of studies that have considered this factor. However, there are some studies from the field of physical activity that have linked SDT to factors with similar characteristics to those described by the novelty such as: the search for new sensations [18], curiosity [19] and desire [20]. Although it is true that the approach that researchers have used of these variables is close to what has been defined as novelty, the focus of these investigations is different in terms of a possible establishment of a new basic psychological need (for a greater understanding, see González-Cutre, et al., [11]).

Despite this dual validation of basic psychological needs, studies on them are highly fragmented. To such an extent that the study of the inexistence of a questionnaire that takes into consideration both aspects (see, [13,14,21,22]). In this sense, a study centred on psychological needs towards life and carried out by Longo, Alcaraz-Ibáñez and Sicilia [23] with university students showed the importance of uniting both valences in order to have a general vision of the influence of psychological needs and their effects.

Based on this background, the objective that we propose is to adapt and validate the Basic Psychological Needs Scale (BNPS) to the Spanish context of physical exercise, incorporating the fourth novelty need. Joining in the same scale the satisfaction and frustration of the psychological needs in order to measure both the positive and negative side. The CFA of the proposed instrument is expected to provide adequate adjustment rates for the eight-factor correlated model and the higher-order model. Both models are expected to be invariant with respect to gender and age. In addition, the internal consistency of the factors and their temporal stability is expected to be adequate. A structural equation model will be made to show evidence of validity of the BPNS criteria by analyzing the predictive relationships of each of the psychological needs with respect to the intrinsic motivation for physical activity.

2. Method

2.1. Participants

A total of 2372 people between the ages of 16 and 48 (*M* = 28.39; *SD* = 12.30) taking part in physical activity in various sports centres in Andalusia.

In addition, a different sample from the first one participated in the present study in order to carry out the temporal stability, which was made up of 871 persons between 17 and 51 years old (*M* = 27.65; *SD* = 9.68). This second group completed the scale on two occasions, with a time interval of two weeks between both data collection.

A third independent sample of 2138 people aged 16–49 was used to analyse the predictability of the scale through a structural equation model.

The sample used was non-probabilistic incidental, depending on those sports centres and people who had access to them.

2.2. Instruments

2.2.1. Basic Psychological Needs Scale (BPNS) towards Physical Activity

Satisfaction of basic psychological needs. The validated and adapted version of the Satisfaction of Basic Psychological Needs Scale was used in the exercise by Sánchez and Nuñez [21] whose factors are autonomy, competence, and relationship. The final scale comprises a total of 12 items distributed among the three factors that make up the scale: autonomy, competence, and relationship. In order to measure the satisfaction of novelty towards physical exercise, the items corresponding to the factor with the same name belonging to the scale of Satisfaction of Psychological Needs towards Physical Education classes of Trigueros, et al., [13] were adapted. This factor is made up of six items.

Frustration of psychological needs. The adapted version of the Psychological Needs Frustration Scale was used in physical exercise (PNFS; [22]). The scale was preceded by the heading "In my PE classes..." and consists of 12 items, distributed equally among each of the factors that make up the scale (i.e., autonomy, competence, relationship with others). In order to measure the frustration of novelty, the items corresponding to the factor with the same name belonging to the scale of Frustration of Psychological Needs were adapted to the Physical Education classes of Trigueros, et al., [14]. This factor is made up of five items.

Each of the above scales is of the Likert type, ranging from 1 (not true at all) to 7 (totally true).

2.2.2. Intrinsic Motivation

The factor with the same name from the Behaviour Regulation in Practice Questionnaire (BREQ-3) by González-Cutre, Sicilia and Alberto Fernández was used [24]. The scale was headed by the following heading, "I do physical exercise..." and the intrinsic motivation factor consisted of 4 items. The questionnaire is of the Likert type, ranging from 0 (nothing true) to 4 (totally true).

2.3. Procedure

Some sports centres were asked to collaborate in the research, so that they could allow us to reach the people who come to the sports centre to do physical exercise and explain to them the objective of the study. In order to participate, it was necessary to fill out the informed consent form. When filling in the questionnaires, we insisted on the anonymity of the answers, emphasizing that they were being asked for their own opinions and that participation was voluntary. A member of the research group was present while people completed the questionnaires to answer any questions they might have. All ethical procedures for data collection were respected, taking about 20 min to complete the questionnaires.

2.4. Data Analysis

To analyze the psychometric properties of the BNPS towards physical exercise, a series of analyses were carried out in order to be able to determine its validity and reliability. Firstly, two confirmatory factor analyses (CFAs) were carried out in order to test the factor structure of the questionnaire. Then, a multi-group analysis was performed in relation to sex and age in order to determine if the questionnaire is understood in a similar way without age or sex being determinants. Subsequently, the statistical-descriptive analysis and the internal consistency analysis were carried out using Cronbach's alpha in order to test the reliability of the instrument and a temporal stability analysis using a test-retest. Finally, a criteria analysis was carried out through a structural equation model, where each of the factors that make up the scale was related to the intrinsic motivation. The statistical packages SPSS 25.0 and AMOS 22.0 (IBM, Armonk, NY, USA) were used for the data analysis.

The maximum likelihood estimation method was used along with the bootstrapping procedure for the AFC and the path analysis. In order to accept or reject the model tested, a set of adjustment indexes was taken into consideration [25]: Since χ^2 is very sensitive to sample size, χ^2/df was used and values below 3 were considered acceptable; IFC (Comparative Fit Index) and IFI (Incremental Fit Index) show a good fit with values equal to or higher 0.95; RMSEA (Root Mean Square Error of Approximation) plus its confidence interval (CI) at 90%, and SRMR (Standardized Root Mean Square Residual) are considered acceptable with values equal to or less than 0.06 and 0.08, respectively.

3. Results

3.1. Confirmatory Factor Analysis

The fit indices of the model tested (Figure 1) revealed the following settings: χ^2 (532. N = 2372) = 1044.73, $p < 0.001$; χ^2/df = 1.96; CFI = 0.95; IFI = 0.95; RMSEA = 0.052 (CI 90% = 0.046–0.057); SRMR = 0.032. Standardized regression weights ranged from 0.70 to 0.86 and were statistically significant ($p < 0.001$).

Once the model was determined, a higher order model was tested (e.g., the eight first order factors converging into two higher order factors called frustration and satisfaction). The adjustment indices of this model are as follows (Figure 2): χ^2 (551. N = 2372) = 958.04, $p < 0.001$; χ^2/df = 1.74; CFI = 0.96; IFI = 0.96; RMSEA = 0.052 (CI 90% = 0.047–0.058); SRMR = 0.041. All standardized regression weights were significant ($p < 0.001$), with 0.85 for frustration of competence, 0.84 for frustration of autonomy, 0.72 for frustration of relatedness, 0.81 for frustration of novelty, 0.56 for satisfaction of competence, 0.82 for satisfaction of autonomy, 0.79 for satisfaction of relatedness, and 0.78 for satisfaction of novelty. As for the correlations between the higher order factors, they were −0.51, being statistically significant ($p < 0.001$).

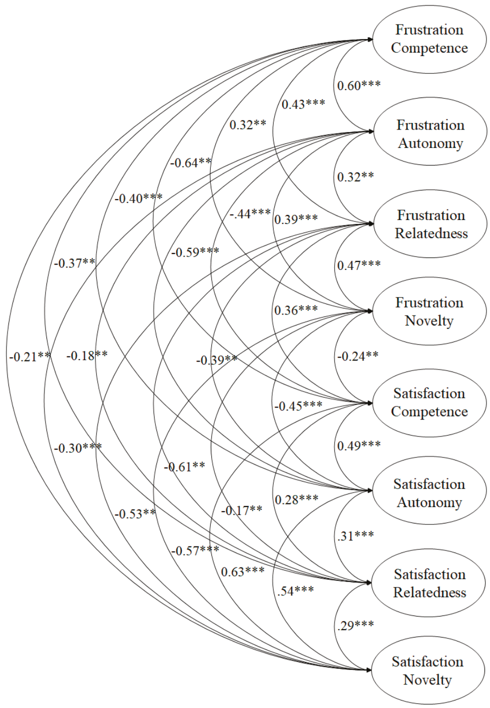

Figure 1. Confirmatory factor analysis of the Basic Psychological Needs Scale (BPNS).

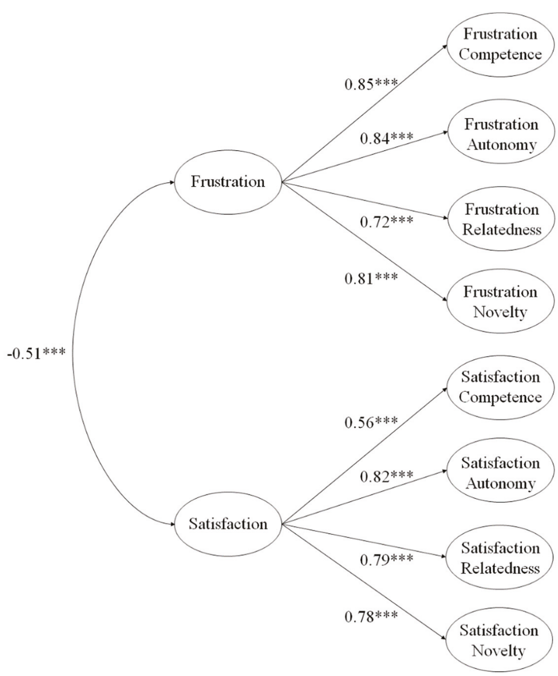

Figure 2. Higher order confirmatory factor analysis of the BPNS.

Gender and Age Invariance Analysis

A multi-group analysis was carried out in order to find out whether the factor structure of the model is invariant with respect to gender and age. As shown in Tables 1 and 2 for the eight-factor model, no significant differences were observed in the statistic $\chi 2$ between model 1 (non-constrained model) and model 2 (model with invariant measurement weights) and yes with respect to model 3 (invariant structural covariance models) and model 4 (invariant residual measures model). In addition, Tables 1 and 2 show the adjustment rates for the six models compared within the higher-order two-factor structure. Likewise, no significant differences were found between model 1 and model 2 and whether there were significant differences between model 3, model 4 (structural covariance model), model 5 (structural invariant residuals model), and model 6 (invariant residual measures model). The differences between models 1 and 2 constitute a minimum criterion to be able to say that the factor structure of the questionnaire, a four-factor model and the higher order model, is invariant with respect to gender [26].

Table 1. Multi-group Gender Invariance Analysis.

Eight-Factor Primary Order Model									
Models	χ^2	*df*	χ^2/df	$\Delta\chi^2$	Δdf	**CFI**	**IFI**	**SRMR**	**RMSEA (CI 90%)**
Model 1	1668.77	1158	1.56	-	-	0.95	0.95	0.037	0.046 (0.042–0.050)
Model 2	1715.52	1160	1.57	46.75	27	0.95	0.95	0.037	0.046 (0.042–0.050)
Model 3	1768.97	1162	1.57	100.20 **	63	0.94	0.94	0.037	0.046 (0.042–0.050)
Model 4	1847.72	1166	1.59	178.95 ***	98	0.94	0.94	0.039	0.047 (0.043–0.051)
Higher-Order Two-Factor Model									
Models	χ^2	*df*	χ^2/df	$\Delta\chi^2$	Δdf	**CFI**	**IFI**	**SRMR**	**RMSEA (CI 90%)**
Model 1	1720.87	1102	1.56	-	-	0.95	0.95	0.035	0.046 (0.041–0.050)
Model 2	1769.50	1129	1.57	48.62	27	0.95	0.95	0.035	0.046 (0.041–0.050)
Model 3	1772.28	1135	1.56	51.41 *	33	0.95	0.95	0.035	0.046 (0.041–0.050)
Model 4	1773.28	1138	1.56	52.41 *	36	0.95	0.95	0.036	0.046 (0.041–0.050)
Model 5	1801.24	1146	1.57	80.37 **	44	0.95	0.95	0.035	0.046 (0.041–0.050)
Model 6	1887.46	1181	1.60	166.59 ***	79	0.94	0.94	0.037	0.046 (0.043–0.051)

Note: Comparative Fit Index (CFI); Incremental Fit Index (IFI); Root Mean Square Error of Approximation (RMSEA); Standardized Root Mean Square Residual (SRMR); Confidence Interval CI; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 2. Multi-group Age Invariance Analysis.

Modelo de Ocho Factores de Orden Primario									
Models	χ^2	*df*	χ^2/df	$\Delta\chi^2$	Δdf	**CFI**	**IFI**	**SRMR**	**RMSEA (CI 90%)**
Model 1	1831.39	1064	1.72	-	-	0.95	0.95	0.041	0.065 (0.060–0.070)
Model 2	1858.07	1091	1.70	26.70	27	0.95	0.95	0.043	0.064 (0.059–0.069)
Model 3	1945.13	1127	1.73	113.75 **	63	0.95	0.95	0.044	0.064 (0.060–0.070)
Model 4	2001.50	1162	1.72	170.12 ***	98	0.94	0.94	0.047	0.065 (0.060–0.070)
Higher-Order Two-Factor Model									
Models	χ^2	*df*	χ^2/df	$\Delta\chi^2$	Δdf	**CFI**	**IFI**	**SRMR**	**RMSEA (CI 90%)**
Model 1	1914.13	1102	1.74	-	-	0.95	0.95	0.045	0.066 (0.060–0.071)
Model 2	1942.19	1129	1.72	28.06	27	0.95	0.95	0.045	0.065 (0.060–0.070)
Model 3	1945.80	1135	1.71	31.68	33	0.95	0.95	0.044	0.065 (0.060–0.069)
Model 4	1955.25	1138	1.72	41.12	36	0.95	0.95	0.044	0.065 (0.060–0.070)
Model 5	1989.48	1146	1.74	75.35 **	44	0.94	0.94	0.044	0.066 (0.061–0.070)
Model 6	2045.43	1181	1.73	131.30 ***	79	0.94	0.94	0.044	0.065 (0.061–0.070)

Note: ** $p < 0.01$; *** $p < 0.001$.

3.2. Descriptive Statistics, Correlation and Reliability Analysis

In Table 3, the means, standard deviation and bivariate correlations are shown. The correlations reflected a positive association between those factors linked to each other and a negative association between the opposites. In addition, Table 3 shows that the internal consistency analysis reflected Cronbach's alpha values greater than 0.70 [27,28] for each of the factors.

In the temporal stability analysis, intra-class correlation coefficients (ICC) and their confidence intervals (CI) were calculated.

3.3. Criteria Validity Analysis

In order to analyze the criterion validity of the BPNS, a structural equation model was made to analyze the predictability of the scale. The fit indices of the model tested (Figure 3) revealed the following fit indices: χ^2 (51. N = 2138) = 147.67, $p < 0.001$; χ^2/df = 2.89; IFC = 0.96; IFI = 0.96; RMSEA = 0.051 (CI 90% = 0.049–0.061); SRMR = 0.038.

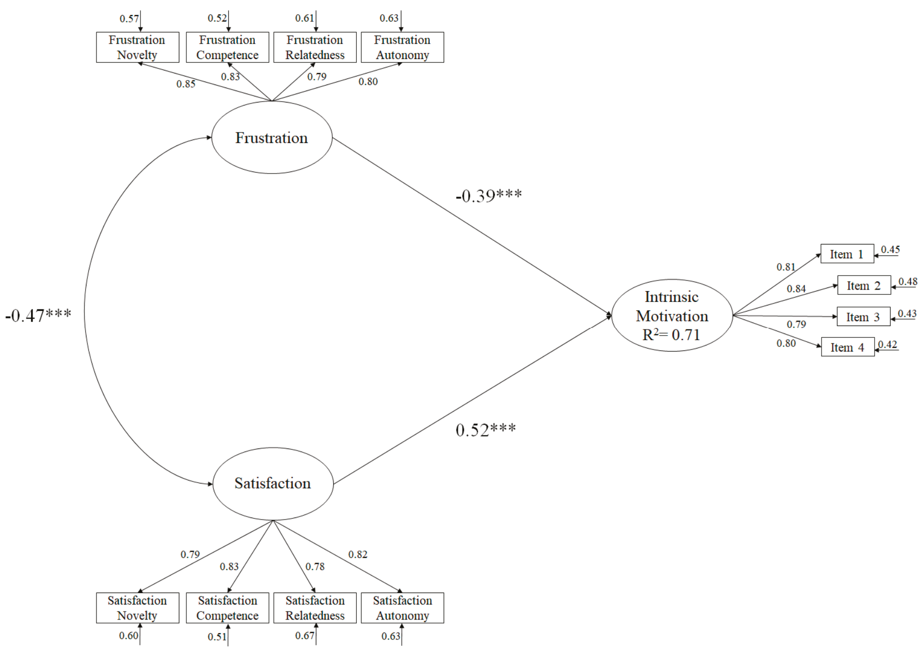

Figure 3. Structural equation model.

Table 3. Descriptive Statistics and Correlations between all BPNS Factors.

Factors	*M*	*SD*	α	1	2	3	4	5	6	7	8	9	10	ICC
1. Frustration of autonomy	1.88	1.10	0.87		0.62 ***	0.73 ***	0.43 ***	0.82 ***	−0.45 **	−0.25 ***	−0.41 **	−0.12 **	−0.40 **	0.77 (IC = 0.71–0.86)
2. Frustration of competence	2.17	1.14	0.86			0.81 ***	0.42 ***	0.84 ***	−0.20 **	−0.12 *	−0.15 *	−0.32 **	−0.74 **	0.83 (IC = 0.78–0.85)
3. Frustration relatedness	1.89	1.12	0.85				0.40 ***	0.83 ***	−0.34 ***	−0.37 ***	−0.23 *	−0.54 **	−0.48 **	0.81 (IC = 0.78–0.83)
4. Frustration novelty	2.00	0.95	0.82					0.80 ***	−0.36 ***	−0.56 ***	−0.41 ***	−0.19 *	−0.45 **	0.80 (IC = 0.77–0.83)
5. Frustration	1.99	1.12	0.88						−0.37 **	−0.32 **	−0.84 **	−0.13 ***	−0.73 ***	0.85 (IC = 0.69–0.85)
6. Satisfaction Autonomy	5.23	0.86	0.82							0.63 ***	0.51 ***	0.68 ***	0.85 ***	0.75 (IC = 0.71–0.83)
7. atisfaction of the competence	5.31	0.91	0.81								0.56 ***	0.62 ***	0.83 ***	0.80 (IC = 0.79–0.84)
8. Satisfaction relatedness	5.40	0.67	0.83									0.48 ***	0.81 ***	0.83 (IC = 0.79–0.86)
9. Satisfaction novelty	5.11	0.87	0.85										0.80 ***	0.86 (IC = 0.81–0.88)
10. Satisfaction	5.26	1.03	0.88											0.89 (IC = 0.81–0.90)

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

4. Discussion

The present study aims to determine the validity of the factor structure, internal consistency, temporal stability and predictive validity of the BPNS towards physical exercise. The results have shown that the BPNS as an instrument with adequate validity and reliability to evaluate the positive and negative aspects of basic psychological needs towards physical exercise, also incorporating novelty. In this way, an effective tool is available that can help researchers and professionals to understand in greater depth the predictive effects of basic psychological needs on the adaptive and maladaptive behaviors of people who engage in any type of physical activity [29,30].

The first CFA revealed that the factorial structure of the BPNS showed adequate adjustment rates for the eight-factor model, showing a positive relationship between those needs with the same root and a negative relationship between those needs with different roots. These results are similar to various studies that have been carried out to date [10–12,14], and are in line with the postulates of the SDT [5,8] where the reciprocity between each of the psychological needs is defended, also incorporating the novelty, continuing the path of previous studies (e.g., González-Cutre et al., [11]; Kashdan, and Silvia, [31]). As for the second CFA, the factor structure of the higher-order dual model revealed acceptable adjustment rates, showing a negative correlation between frustration and satisfaction. This model is interesting because it supports the use of an overall value composed of the mean of the sub-factors, which can be used by researchers to simplify models where several constructs are present. Furthermore, its use is justified since a study by Gagné, Ryan, and Bargmann [32] suggested that needs tend to function as a single "body" in different situations.

On the other hand, the reliability and temporal stability analyses revealed acceptable adjustment rates for all eight subscales and higher order factors. As for the mutli-group analysis, it showed that the structure of the eight-factor model and the higher-order model of the BPNS were invariant with respect to gender and age. These results support the use of the questionnaire in future research where it is intended to compare means between boys and girls as well as between different ages.

Finally, evidence of predictive validity for the scale was found through the structural equation model. This analysis showed that each of the factors pertaining to the satisfaction of basic psychological needs positively predicted the intrinsic motivation, while the frustration of basic psychological needs predicted it negatively. These results are similar to previous studies where satisfaction of psychological needs was positively related to intrinsic motivation [33,34] and frustration of psychological needs was negatively related to intrinsic motivation [35,36]. These relationships appear to support the postulates of SDT that the frustration of psychological needs may lead to the search for a collateral satisfaction that compensates for this feeling of frustration by producing a series of disadaptive consequences or inhibition that may be contrary to personal well-being, and conversely, the satisfaction of basic psychological needs is closer to adaptive behaviors and continued participation that promote personal well-being [37].

Despite the results achieved by this study, a number of limitations should be highlighted. In this sense, future studies should continue to analyze the factorial structure of the questionnaire since the creation and/or adaptation of a questionnaire is a continuous process that requires an in-depth analysis of its functioning in different populations with equally different sociodemographic characteristics.

5. Conclusions

BPNS towards physical this scale exercise offers researchers a valid and effective tool that can help measure people's perceived basic psychological needs towards physical exercise. Moreover, it is in line with the postulates of the SDT and will allow further assessment of the contextual factors inherent to physical activity can undermine or promote psychological well-being by promoting personal development.

Author Contributions: Conceptualization, R.T.; Data curation, C.M.-A. and R.L.-L.; Formal analysis, J.M.A.-P.; Funding acquisition, J.F.Á.; Investigation, A.J.C.; Methodology, R.T.; Project administration, A.J.C.; Resources,

J.F.Á., J.M.A.-P. and P.R.; Software, R.L.-L.; Visualization, R.T.; Writing—original draft, R.T.; Writing—review & editing, J.M.A.-P. and P.R. 'All authors have read and agreed to the published version of the manuscript.

Funding: Convocatoria Ayudas a Transferencia de Investigación "Transfiere" 2018 (Ref. 001364).

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Understanding Physical Activity Intentions in Physical Education Context: A Multi-Level Analysis from the Self-Determination Theory

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Received: 27 December 2019; Accepted: 24 January 2020; Published: 28 January 2020

Abstract: Using self-determination theory as a framework, we aimed to study the relationships between perceived need support and need satisfaction with self-determined motivation and extracurricular physical activity intentions in the physical education (PE) classroom, including sex and out-of-school sport participation as moderators. Additionally, we aimed to test whether a need-supportive classroom environment in PE moderates these associations. Participants were 1259 students (556 males) aged between 12 to 16 years (Mage = 13.46 years; SD = 0.74) from 77 PE classes. At the student level we found (a) need satisfaction to predict positively autonomous motivation and negatively amotivation, and (b) autonomous motivation to predict positively and amotivation to predict negatively intentions to undertake extracurricular physical activities. At the classroom level, in need-supportive classes males benefit more than females in terms of increased autonomous motivation while females benefit more than males in terms of decreased amotivation. Finally, class-level perceived need support moderated (i.e., attenuated) the negative association between need satisfaction and amotivation and between amotivation and intentions. These results suggest a buffering role that a need-supportive classroom environment may have on students' motivation and behavior.

Keywords: need support; need satisfaction; motivation; physical activity promotion

1. Introduction

Physical inactivity has been growing to alarming rates in developed countries with 81% of the adolescents failing to meet the minimum amounts of physical activity (PA) recommended by the World Health Organization [1]. To address this problem, experts have pointed out Physical Education (PE) classes as a suitable context for the promotion of PA in adolescence [2]. In particular, the learning environment of the PE classroom, the degree to which the students satisfy their needs, their quality of motivation, and their attitudes toward PE have been highlighted as important predictors of PA intentions [3,4]. It remains unknown however whether a positive and caring learning environment relates to quality of motivation and extracurricular PA intentions in a similar way among both males and females and among students who already differ in PA levels. This is an interesting research question because we are unaware whether some students may benefit more (or less) from a need-supportive PE environment (i.e., that allocates resources to promote basic psychological needs satisfaction).

1.1. Self-Determination Theory

To examine which factors related to PA intentions, numerous studies have relied on self-determination theory (SDT) [5]. According to SDT, motivation lies on a continuum that ranges from higher to lower levels of self-determination, which refers to the degree to which behaviors are volitionally undertaken. The highest degree of self-determination is called intrinsic motivation, and manifests when an adolescent performs an activity out of pleasure, that is, as an end in itself. A lesser form of self-determined motivation is identified regulation, which occurs when a person ascribes social and personal importance in the activity he or she performs. Next, is introjected regulation, which characterizes someone who carries out an activity to avoid feelings of guilt (that would appear if he or she did not do so), or to accumulate feelings of pride. An even less self-determined type is external regulation, which defines activities that people performed to get a reward or to avoid punishments. Intrinsic motivation and identified regulation represent autonomous motivation—that form of motivation where the person volitionally undertakes an activity. In contrast, introjected and external regulation represent controlled motivation—that form of motivation where one acts because of some internal or external psychological pressures. Finally, the lowest level of self-determination is amotivation, defined by the absence of intentions to undertake a behavior either because of helplessness or lack of interest; when amotivated, a subject does not know exactly why he or she keeps practicing. Previous studies in PE have shown autonomous motivation to relate to positive outcomes, such as effort, vitality, and intentions to undertake extracurricular PA, whereas controlled motivation and amotivation have been related to negative consequences, such as boredom or unhappiness [6].

SDT argues that autonomous motivation is promoted when the basic psychological needs for autonomy, competence, and relatedness are satisfied [5]. The need for autonomy refers to feelings of volition and the sense that one has personal control over one's own behaviors; the need for competence represents a sense of being successful when dealing with a task; the need for relatedness is defined by feelings of connection and belongingness within the social context. Several studies conducted in the PE context have shown that who satisfied their needs report more autonomous and less controlled motivation or amotivation [6].

We ask, what is it that makes students well satisfied in PE which in turn makes them more autonomously motivated? The SDT claims that social context plays an important role in the promotion of need satisfaction [5]. In this regard a PE teacher can satisfy their students' need for autonomy, by using specific strategies such as taking the students' perspective, providing choices to them, and transferring to them some responsibility in decision-making [7]. Likewise, to satisfy their students' need for competence, PE teachers should aim at optimizing students' perception of skills through activities that are adjusted to their level; PE teachers should also provide sufficient time to their students to achieve the proposed goals, and deliver positive feedback to them by acknowledging their efforts and progress [7]. Finally, to satisfy their students' need for relatedness, PE teachers should create learning environments that promote feelings of inclusion, integration, trust, and respect among their students and between themselves and their students [8]. Previous studies have found that students who perceive the learning environment of the PE class as need-supportive show greater need satisfaction and in turn more autonomous motivation, less amotivation, and more intentions to increase their PA levels by undertaking for instance some out-of-school sport activities [6].

In our study, we investigate whether the perceived learning environment and basic need satisfaction relate to the quality of motivation and extracurricular PA intentions in a similar way among males and females and among students who already differ in their PA levels. Investigating whether these relations are similar across all students or not would help us design more effective intervention programs in the PE class that will be especially designed for males (or females) or for those who are less active in PA.

1.2. The Role of Gender and PA Levels in PE

Various studies have shown that males and students who undertake some out-of-school sport activities may be more autonomous and less amotivated to undertake extracurricular PA than females and students who are less physically active. For instance, males were found to report higher levels of autonomous motivation and less amotivation than males within PE context [9–13]. Likewise, Ntoumanis [12] found that physically active students score higher in autonomous motivation and lower in amotivation than non-active students (but see also Viira and Koka and Shen [14,15]). Regarding intentions to undertake extracurricular PA, no clear pattern was found as some researchers found no gender differences [4,12], whereas some others [11] found males to score higher than females. In sum, gender and doing out-of-school sports seem to relate to autonomous motivation and intentions to undertake extracurricular PA.

We aimed to extend this line of research by examining whether such differences are invariant across different PE motivational environments; that is, whether PE classroom environments attenuate or aggravate students' differences in autonomous motivation, amotivation, and PA intentions among males versus females and among students who are physical active versus those who are not. We were driven to examine this issue from some prior studies which have shown that perhaps males and females are not equally affected by the social contexts. In his seminal work, for instance, Deci [16] found praise to result in higher intrinsic motivation (as reflected through free-choice behavior) among males but not among females. A similar indirect hint that the context may differentially associate with people's functioning comes from a few SDT-based diary studies which have shown that some people may benefit more under certain conditions. For example, Moller, Deci, and Elliot [17] revealed that the positive association between day-to-day positive affect and relatedness need satisfaction was even stronger among people who in general had satisfying relationships in their lives. These findings imply that the expected positive associations between determinants of autonomous motivation and optimal functioning may vary, depending on certain situational or personal characteristics. Therefore, more research is needed to uncover under what circumstances who benefits more.

1.3. The Present Research

To pursue our aims, we set up two sets of multilevel models. The first set contained types of motivation (i.e., autonomous motivation, controlled motivation, and amotivation) as dependent variables. In those models, we investigated the degree to which basic need satisfaction, gender and doing out-of-school sport activities predict quality of motivation. Building on this first set of models, the second part examined whether types of motivation (i.e., the dependent variables in the first set of models) predict, along with gender and doing-out-of-school sport activities intentions to undertake extracurricular PA. Moreover, in both sets of models we examined whether the PE classroom climate would predict quality of motivations (i.e., the first set of models) and PA intentions (i.e., the second model). More important, we examined whether PE classroom climate would moderate the relations of need satisfaction, gender, and doing out-of-school sport activities to quality of motivation (first set of models) or the relations between quality of motivation, gender, and doing-out-of-school sport activities to intentions to undertake extracurricular PA (second set of models).

We formulated the following hypotheses. First, we relied on prior empirical evidence and hypothesized that doing out-of-school sport activities, being male, and experiencing need satisfaction would predict positively autonomous motivation and negatively controlled motivation and amotivation (Hypothesis 1). Similarly, we hypothesized that the same predictors (i.e., sport participation status, gender, and needs satisfaction) along with autonomous motivation would predict positively and that controlled motivation and amotivation predict negatively intentions to undertake extracurricular PA (Hypothesis 2). At the contextual level (i.e., classroom), we hypothesized that need-supportive environment (as defined by the aggregate scores of students' perceptions of need support) would explain between-class differences in autonomous motivation, controlled motivation, amotivation, and intentions. Specifically, we expected that students who belonged to high need-supportive PE classes would report more autonomous motivation, and intentions and less controlled motivation and amotivation (Hypothesis 3). Finally, as we had no particular hypothesis regarding who benefits more in a need-supportive learning environment, we tested in a more explorative fashion whether need-supportive learning environment would moderate (a) the relations of gender, out-of-school sport activities status, and need satisfaction to autonomous motivation, controlled motivation, and amotivation and (b) the relations of gender, out-of-school sport participation status and the three types of quality of motivation to intentions to undertake extracurricular PA in the future.

2. Materials and Methods

2.1. Participants

Participants of this project were 1346 students nested into 32 randomly selected public compulsory schools situated in the region of Extremadura (Spain). It is a representative sample for the population of Extremadura ($n_{population}$ = 46,231; 95% confidence interval; margin of error = 3%). We excluded data from classes with less than 5 students (to prevent the confounding of level-2 effects) and students who did not fill out all study variables or showed unusual response patterns and response processes (n = 87). The sample of this particular study was composed of 1259 students (44.2% males) aged between 12 to 16 years (*M* = 13.46; *SD* = 0.74) belonging to 100 PE classes (mean number of students per class was 12.59). The average number of PE classes per school was 3.66.

2.2. Instruments

2.2.1. Perceived Need Support

The Questionnaire of Basic Psychological Needs Support in Physical Education [18] was used to asses perceived autonomy, competence, and relatedness support. After reading the statement "In Physical Education classes, my teacher ... " the participants rated 12 items, four of which tapping into perceived autonomy support (α = 0.77; e.g., " ... often asks us about our preferences with respect to the activities we carry out"), another four competence support (α = 0.71; e.g., " ... offers us activities based on our skill level"), and another four relatedness support (α = 0.80; e.g., " ... promotes good relationships between classmates at all times"). An overall score of perceived need support was computed by averaging the 12 items (α = 0.88).

2.2.2. Need Satisfaction

Autonomy, competence, and relatedness need satisfaction were assessed using the Spanish adaptation for PE context [19] of the Basic Psychological Needs in Exercise Scale (BPNES) [20]. This instrument has 12 items (4 items per factor) that follow the initial statement "In my PE class ... " and measure the satisfaction of the basic psychological needs of autonomy (α = 0.79; e.g., " ... we carry out exercises that are of interest to me"), competence (α = 0.80; e.g., " ... I carry out the exercises effectively), and relatedness (α = 0.83; e.g., " ... my relationship with my classmates is friendly"). An overall score of need satisfaction was computed by averaging the 12 items (α = 0.88).

2.2.3. Type of Motivation

The different types of behavioral regulations were assessed using the Questionnaire of Motivation in Physical Education Classes (CMEF) [21]. We used 20 items of the questionnaire (4 items per behavioral regulation) that followed the statement "I take part in this PE class ... ", exploring: intrinsic motivation (α = 0.83; e.g., "Because PE is fun"), identified regulation (α = 0.81; e.g., "Because I can learn skills that could be used in other areas of my life), introjected regulation (α = 0.76; e.g., "Because I feel bad if I am not involved in the activities), external regulation (α = 0.80; e.g., "Because I want the teacher to think that I am a good student"), and amotivation (α = 0.66; e.g., "But I think that I'm wasting my time with this subject").

A confirmatory factor analysis with a five latent factor model yielded acceptable fit ($\chi 2$ (160; *N* = 1259) = 504.46, $p < 0.01$, *CFI* = 0.952, *SRMR* = 0.040, *RMSEA* = 0.041 (90% *CI*: 0.037–0.045)). The five factors however failed to accurately reproduce, as expected, the simplex pattern as external regulation was positively related to both intrinsic motivation ($r = 0.36$, $p < 0.01$) and identified regulation ($r = 0.30$, $p < 0.01$) and as amotivation was negatively associated with all the other four types of behavioral regulations, including external regulation ($r = -0.11$, $p < 0.01$). Additionally, after computing a score of autonomous motivation by averaging intrinsic motivation and identified regulation ($\alpha = 0.89$) and of controlled motivation by averaging introjected and external regulation ($\alpha = 0.85$), we found in our preliminary analyses a positive, and rather moderate, relation of controlled motivation to perceived need support ($r = 0.40$, $p < 0.01$), need satisfaction ($r = 0.48$, $p < 0.01$), and autonomous motivation ($r = 0.52$, $p < 0.01$). This finding suggested that controlled motivation as assessed through the respective items may not fully capture the theorized construct. Retrospective inspection of the controlled motivation items confirmed our suspicion as most of them tapped into introjected regulation, but not external regulation. We therefore decided to drop controlled motivation from further analyses.

2.2.4. Extracurricular PA Intentions

To measure students' intentions to undertake PA outside of the school curriculum, one item was included: "In the coming years, I intend to participate in extracurricular sport/physical activity". The questionnaire specified that "sport participation" refferred to participating in PA or a sport on a regular basis (at least twice a week). Previous research has implemented single-item scales effectively [3,15,22].

For all of the above questionnaires, participants expressed their level of agreement using a 5-point Likert-type scale that ranged from 1 (strongly disagree) to 5 (strongly agree).

2.2.5. Out-of-school Sport Participation Status

Doing sports as an activity outside of school was assessed through the question: "Do you practice any sport or physical activity outside of school?". Students had to answer yes or no. The questionnaire clarified that students should answer "yes" if they practiced some form of regular Sport/PA at least twice a week.

2.3. Procedure

The present study was approved by the ethical committee of the host university and was supported by the Spanish Professional Association of PE teachers, which enabled us to approach the participating PE teachers. Then, the head researcher contacted the schools to explain the objectives of the study and to request their participation. PE teachers were informed that the purpose of the study and parental consent was also obtained for all participants before commencing the study. All participants were treated according to the ethical guidelines of the American Psychological Association with regards to consent, confidentiality, and anonymity of responses. The participants assented and completed the questionnaire online in the classroom during a class hour via Google Doc, which participants could access via a link provided by the researchers. In all cases, the classrooms were equipped with computers with an internet connection, and each student had approximately 2530– minutes to complete the questionnaires.

2.4. Plan of Data Analysis

Initially, descriptive statistics (means and standard deviation) and bivariate correlations between observed variables were computed. Given the nested structure of our data (as students were nested into classrooms, nested into PE teachers), we set up in two steps three separate three-level models. In the first step we examined the degree to which students' autonomous motivation (Model 1) and amotivation (Model 2) towards PE class-related activities could be explained (a) at the individual level, by students' need satisfaction as well as by gender, out-of-school sport participation status, and (b) at the classroom level by the aggregate scores of perceived need support. Through the same model we also explored whether perceived need support as some classroom characteristics would moderate the hypothesized associations of gender, out-of-school sport participation status, and need satisfaction to autonomous motivation and amotivation. In the second step, we examined to what extent intentions (Model 3) could be explained, following the same process than models 1 and 2, but including autonomous motivation and amotivation at the individual level (and excluding students' need satisfaction). All the analyses were conducted through HLM6 software package (version 6, Lincolnwood, Illinois, EE. UU) [23].

At the classroom level the aggregate score of perceived need support was entered grand-centered, whereas at the student level gender (0 = males; 1 = females) and out-of-school sport participation status (0 = no; 1 = yes) were entered uncentered, while need satisfaction were entered group-mean centered. Additionally, all the slopes were initially estimated as randomly varying from classroom to classroom and were fixed, in a stepwise fashion, unless they were statistically nonsignificant. No predictors were included at the PE teacher level because we had no particular information about the PE teachers, because the relatively small number of the units at that level (i.e., the PE teachers) might have jeopardized the stability of the coefficients [24], and because we opted for more parsimonious models.

3. Results

3.1. Preliminary Analyses

Descriptive statistics and zero-order correlations are presented in Table 1. As can be noticed, females tended to report less out-of-school sport activities and less intentions to undertake such extracurricular PA in the future; also, females reported less need satisfaction and autonomous motivation. Perceived need support, need satisfaction, autonomous motivation as well as intentions to undertake extracurricular PA in the future were all positively intercorrelated and they were all negatively related to amotivation.

Table 1. Means, standard deviations, and bivariate correlations of the observed variables.

Variables	1	2	3	4	5	6	7
1. Gender (males vs. females)	-						
2. Out-of-school sport participation	–0.27 **	-					
3. Perceived need support	–0.01	0.05	-				
4. Need satisfaction	–0.10 **	0.20 **	0.67 **	-			
5. Autonomous motivation	–0.17 **	0.22 **	0.59 **	0.70 **	-		
6. Amotivation	0.00	–0.12 **	–0.31 **	–0.39 **	–0.48 **	-	
7. Intentions to undertake extracurricular PA	–0.18 **	0.36 **	0.33 **	0.53 **	0.51 **	–0.31 **	-
M	0.56	0.69	4.23	4.03	4.22	1.71	4.17
SD	0.50	0.46	0.66	0.68	0.76	0.85	1.14

Note. ** $p < 0.01$. Gender (0 = males; 1 = females) and out-of-school sport participation status (0 = no; 1 = yes) are dummy coded. PA: physical activity

3.2. Main Analyses

3.2.1. Autonomous Motivation

Regarding the autonomous motivation model (Model 1) the results are shown in Table 2 (left column). At the student level, need satisfaction related positively to autonomous motivation. This finding provided some support of Hypothesis 1. In addition, gender was negatively (γ_{100} = −0.12, SE = 0.04, $p < 0.01$) and out-of-school sport participation status was positively associated (γ_{200} = 0.12, SE = 0.05, $p < 0.05$) to autonomous motivation. These findings, addressing reveal that, on average, females and students who were not doing out-of-school sport activities reported lower levels of autonomous motivation. At the classroom level, perceived need support predicted positively, though marginally, autonomous motivation (γ_{010} = 0.53, SE = 0.27, p = 0.05) providing thus some support to Hypothesis 3.

Table 2. The multilevel model predicting autonomous motivation and amotivation.

Fixed Effects		**Autonomous Motivation Coefficient**	**(*SE*)**	**Amotivation Coefficient**	**(SE)**
Intercept,	γ_{000}	4.25	(0.05)	1.81	(0.07)
Student-level predictors					
Gender (males vs. females)	γ_{100}	−0.12 **	(0.04)	−0.08	(0.06)
Out-of-school sport participation status,	γ_{200}	0.12 *	(0.05)	−0.07	(0.06)
Need satisfaction	γ_{300}	0.70 **	(0.03)	−0.42 **	(0.05)
Classroom-level predictors					
Need supportive classroom	γ_{010}	0.53^{05}	(0.27)	−0.11	(0.19)
Student-level X class-level interactions					
Need supportive classroom X Gender	γ_{110}	0.67 **	(0.17)	0.55^{06}	(0.29)
Need supportive classroom X Out-of-school sport participation status	γ_{210}	0.04	(0.25)	0.14	(0.17)
Need supportive classroom X Need satisfaction	γ_{310}	-0.24^{07}	(0.13)	0.44 *	(0.17)
Random effects					
Intercept	r_{0j}	0.05 **		0.01 **	
Out-of-school sport participation status slope	r_{2j}	0.01 *		-	
Need satisfaction slope	r_{3j}	0.03 **		0.05 **	
Intercept –Need supportive classroom slope	u_{00}	-		0.06 **	
Gender – Need supportive slope	u_{10}	-		0.04 **	
Student-level variance	ε_{ij}	0.24		0.53	

Note. * $p < 0.05$. ** $p < 0.01$.

As said, classroom's perceived need support was found to moderate also the relation of gender to autonomous motivation ($\gamma_{110} = 0.67$, SE = 0.17, $p < 0.01$). A test of simple slopes indicated that gender was nonsignificant predictor of autonomous motivation in classrooms which were low (i.e., −1 SD below the mean) in perceived need support ($\gamma_{100\ (-1\ \text{SD below the mean in perceived need support})} = -0.08$, SE = 0.08, z = −1.06, $p > 0.05$); instead, it was significant in classrooms which were at average ($\gamma_{100\ (\text{average perceived need support})} = -0.12$, SE = 0.04, z = −2.81, $p < 0.01$) or high levels (i.e., +1 SD above the mean) in perceived need support ($\gamma_{100\ (+1\ \text{SD above the mean in perceived need support})} = -0.16$, SE = 0.07, z = −2.41, $p < 0.01$). This finding suggests that, other things being equal, males benefit more from need-supportive PE classes than females when the classroom was to some extent need-supportive. Instead, there were no differences between males and females when the classroom was not need-supportive.

3.2.2. Amotivation

The results for amotivation (Model 2; see Table 2, right panel), indicated, in support of Hypothesis 1, that need satisfaction were negatively related to amotivation ($\gamma_{300} = -0.42$, $SE = 0.05$, $p < 0.01$). Unlike the model concerning autonomous motivation, however, gender and out-of-school sport participation status did not predict amotivation. The same was true for the classroom-level predictor, perceived need support, as it failed to predict student-level amotivation ($\gamma_{010} = -0.11$, $SE = 0.19$, $p > 0.05$). Therefore, unlike the model concerning autonomous motivation, class-level perceived need support as predictor of amotivation did not provide support in Hypothesis 3.

Yet, classroom-level perceived need support was found to moderate, albeit marginally, the relation between gender and amotivation ($\gamma_{110} = 0.55$, $SE = 0.29$, $p = 0.06$) and the relation between need satisfaction and amotivation ($\gamma_{310} = 0.44$, $SE = 0.17$, $p < 0.05$). A test of simple slopes for gender showed that females reported less amotivation than males in classes which were high in perceived need support ($\gamma_{100\ (+1\ \text{SD above the mean in perceived need support})} = -0.26$, $SE = 0.10$, z = −2.75, $p < 0.01$). Instead, there were no differences between males and females in amotivation in PE classes which were moderate ($\gamma_{100\ (\text{average in perceived need support})} = -0.08$, $SE = 0.06$, z = −1.27, $p > 0.05$) or low in perceived need support ($\gamma_{100\ [-1\ \text{SD below the mean in perceived need support}]} = 0.11$, $SE = 0.14$, z = 0.82, $p > 0.05$). So, although the previous interaction between gender and need-supportive classes showed that males benefit more than females in terms of autonomous motivation, it seems that need-supportive classes are more beneficial for females in terms that they help them decrease their amotivation.

Concerning the moderating effect of perceived need support on the relation between need satisfaction and amotivation, a test of simple slopes indicated that the negative relation between need satisfaction and amotivation was stronger among students belonging to classroom which were low in perceived need support ($\gamma_{300\ \text{(-1 SD velow the mean in perceived need support)}}$ = −0.57, *SE* = 0.06, z = −9.27, $p < 0.01$) than among students belonging to classroom which were at average (γ_{300} ($_{\text{average in perceived need support}}$) = −0.42, *SE* = 0.05, z = −9.10, $p < 0.01$) or high levels of perceived need support (γ_{300} and $_{\text{(+1 SD above the mean in perceived need support)}}$ = −0.27, *SE* = 0.09, z = −3.17, $p < 0.01$).

3.2.3. Intentions to Undertake Extracurricular PA in the Future

Moving to the intentions model (Model 3), the results for this model are displayed in Table 3. At the student level, intentions to undertake extracurricular PA in the future were, in support of Hypothesis 2, associated positively with autonomous motivation (γ_{300} = 0.58, *SE* = 0.05, $p < 0.01$) and negatively with amotivation (γ_{400} = −0.10, *SE* = 0.04, $p < 0.01$), after controlling for gender and extracurricular practice; the latter was, positively associated with intentions (γ_{200} = 0.60, *SE* = 0.09, $p < 0.01$). There were also some gender differences in intentions (γ_{100} = −0.16, *SE* = 0.07, $p < 0.05$) suggesting that females, as compared to males, had less intentions to undertake extracurricular PA in the future.

Table 3. The multilevel model predicting intentions to undertake extracurricular PA.

Fixed Effects		**Intentions to Undertake Extracurricular PA Coefficient**	**(*SE*)**
Intercept,	γ_{000}	3.84	(0.09)
Student-level predictors			
Gender (males vs. females)	γ_{100}	−0.16 *	(0.07)
Out-of-school sport participation	γ_{200}	0.60 **	(0.09)
Autonomous motivation	γ_{300}	0.58 **	(0.05)
Amotivation	γ_{400}	−0.10 **	(0.04)
Classroom-level predictors			
Need supportive classroom	γ_{010}	0.73	(0.44)
Student-level X class-level interactions			
Need supportive classroom X Gender	γ_{110}	−0.19	(0.44)
Need supportive classroom X out-of-school sport participation status	γ_{210}	0.24	(0.43)
Need supportive classroom X Autonomous Motivation	γ_{310}	0.23	(0.26)
Need supportive classroom X Amotivation	γ_{410}	0.41 *	(0.20)
Random effects			
Intercept	r_{0j}	0.20 **	
Out-of-school sport participation status slope	r_{2j}	0.24 **	
Autonomous motivation slope	r_{3j}	0.11 **	
Student-level variance	ε_{ij}	0.77	

Note. * $p < 0.05$. ** $p < 0.05$.

At the classroom level, perceived need-supportive climate failed to predict intentions (γ_{010} = 0.73, *SE* = 0.44, $p > 0.05$) and thus to provide support to Hypothesis 3. Yet, we found perceived classroom-level perceived need support to moderate the relation between amotivation and intentions to undertake extracurricular PA (γ_{010} = 0.41, *SE* = 0.20, $p < 0.05$). A test of simple slopes showed that the relation between amotivation was significant, and negative, among students belonging to low (i.e., 1 *SD* below the mean) or average ($\gamma_{400\ \text{(−1 SD below the mean in perceived need support)}}$ = −0.24, *SE* = 0.07, z = −3.21, $p < 0.01$; and $\gamma_{400\ \text{(average in perceived need support)}}$ = −0.10, *SE* = 0.04, z = −2.85, $p < 0.01$, respectively) but not high (1 *SD* above the mean) need-supportive classes ($\gamma_{400\ \text{(+1 SD above the mean in perceived need support)}}$ = −0.03, *SE* = 0.08, z = 0.49, $p > 0.05$). This finding suggests that high levels of class-level perceived need support attenuated the negative associations between amotivation and intentions to undertake extracurricular PA. A graphical representation of this cross-level interaction is shown in Figure 1.

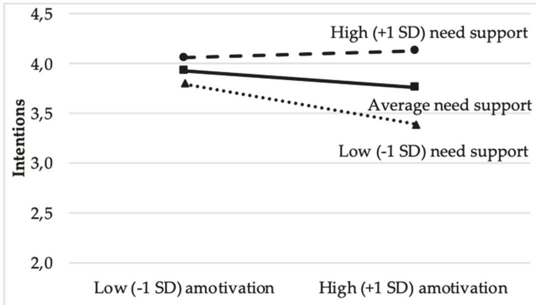

Figure 1. The relation between amotivation and intentions to undertake extracurricular PA as a function of class-level perceived need support.

4. Discussion

Grounded in SDT, our primary purpose of this study was to test the relation of the basic psychological needs to motivation (i.e., autonomous motivation and amotivation) and intentions to undertake extracurricular PA activities in the future. Through multilevel analysis we examined, next to need satisfaction as student-level predictor, the role of perceived need support as a classroom-level predictor of autonomous motivation and amotivation. Moreover, we tested the role of gender and out-of-school sport participation status as potential predictors of autonomous motivation, amotivation, and intentions.

4.1. The role of Need Satisfaction and Motivation

In this study we found that students who highly satisfied their needs for autonomy, competence, and relatedness are more likely to engage in PE class-related activities for self-determined motives, and that they are also less likely to feel amotivated. These findings support our hypothesis 1, and are consistent with SDT postulates [5] and previous studies [6], which emphasize the important role of need satisfaction in PE context. Therefore, PE teachers should allocate their resources on developing such teaching strategies that will satisfy students' autonomy, competence, and relatedness needs.

Regarding the relation between autonomous motivation and amotivation and future intentions to undertake extracurricular PA, our study showed, as it was hypothesized, autonomous motivation to positively predict and amotivation to negatively predict students' intentions to undertake extracurricular PA in the future. These findings are consistent with previous researches [3,4,11,12], and they are also in line with a meta-analysis based on the trans-contextual model [25] that also found a significantly association between autonomous motivation in educational contexts on intentions to practice sport and physical activity ($\beta = 0.19$, $p < 0.001$). Overall, these results highlight the importance of PE context (particularly motivational regulation) in promoting a physically active lifestyle.

4.2. The Importance of Class' Perceived Need Support

At the classroom level, perceived need support positively predicted, albeit marginally, autonomous motivation, whereas it failed to predict amotivation and intentions to undertake extracurricular PA in the future. These findings only confirm Hypothesis 3 with respect to autonomous motivation, and indicate that irrespective of the level of need satisfaction of each student, students who belonged to classrooms that were rated as being need-supportive tended to report that they were autonomous motivated. The importance of a need-supportive environment is also well-established by previous studies. For example, Taylor and Lonsdale [26] found that autonomy support at the classroom level was a positive predictor of competence satisfaction, vitality, and effort. Mouratidis, Vansteenkiste, Sideridis, and Lens [27] also reported that when students experienced a need-supportive teaching style scored higher in interest–enjoyment and vitality than when they experienced a typical (i.e., less need-supportive) teaching style. Regarding lack of relation between class-level need-supportive PE class environment and amotivation, we cannot but speculate that this might be due to the relatively low internal consistency of the scale assessing students' amotivation and (or) to the relatively low mean scores (i.e., floor effects) in students' reports of amotivation (41.5% of the students were assigned the lowest possible score—totally disagree—in amotivation).

With respect to the cross-level interaction between class-level perceived need support on the gender-motivation relations, the results complement prior finding as they show that need-supportive classes were especially beneficial for males in terms of increased autonomous motivation and females in terms of decreased amotivation. These interactions denote that perhaps there might be different routes through which males and females may benefit from a need-supportive environment. However, given the absence of similar finding in the literature more research is needed for this issue. This seems even more imperative because in our research we found no gender differences (i.e., no moderating effects) in the relation between classroom-level perceived need support and intentions.

With respect to out-of-school sport participation status, we did not find classroom-level perceived need support to moderate the relation of out-of-school sport participation status to any of the dependent variable. This finding suggests that irrespective of whether students participated in out-of-school sport activities or not, they equally benefited from a need-supportive learning environment.

Regarding the relation between need satisfaction and autonomous motivation, our results indicate that this positive association tended to be weaker (although marginal) among students belonging in need-supportive PE classes. In terms of the relation between need satisfaction and amotivation, this was significantly less negative among students belonging to need-supportive PE classes. Furthermore, perceived need support emerged as a moderator of the relation between amotivation and future intentions to undertake extracurricular PA. In PE classes which were high in perceived need support, amotivation was not related negatively to intentions; conversely, in PE classes which were low in need support, the relation between amotivation and intentions was even more negative. Taken together, these findings imply that a need-supportive PE class may buffer somehow the negative relations that one should expect between amotivation and need satisfaction or intentions. Perhaps this is because students who belong to perceived need support PE classes are less likely to become, or remain, amotivated—at least in the short term—even when they fail to fully satisfy their needs. Likewise, such students may still express intentions to undertake extracurricular PA in the future, irrespective of their levels of amotivation. It should be noted however that as we found no classroom effects of perceived need-supportive PE class environment on amotivation or intentions, our explanation here awaits further testing. In any case, our findings imply the role that class environment may play in students' quality of motivation. To our knowledge, as no other research has tested the moderating effect of perceived need support as a classroom characteristic on the relation of need satisfaction to different types of motivation, more research is needed to examine this issue.

4.3. Gender Differences in Out-of-School Sport Participation

We also examined the role of gender and out-of-school sport participation status on autonomous motivation and amotivation as well on intentions to undertake extracurricular PA in the future. Regarding gender, results showed, similar to previous studies [9,11–13], that boys reported higher scores on autonomous motivation (but not amotivation) and intentions than girls. In terms of autonomous motivation, the results are consistent with previous studies [9–13]. Based on these findings, PE teachers should especially focus on promoting a self-determined motivation on girls, mainly through satisfying their basic psychological needs. For instance, PE teachers may ask them which activities they prefer to exercise during PE class hours, or they may propose activities that are especially tailored to them with respect to ability-difficulty balance. Equally important, they need to facilitate their social relationships.

In terms of amotivation and the nonsignificant differences that we found, we speculate that although boys may have a higher self-determined motivation than girls, girls are not more amotivated than boys. Although we were not able to include controlled motivation in our study, we speculate that girls may not as much amotivated (i.e., are not bored, or show disinterest and dissatisfaction), but rather they may probably get involved in PE classes for controlled reasons (e.g., to avoid bad feelings, or because this is what they are supposed to do). If so, then PE teachers need to help females' students internalize their locus of causality and thus further internalize their self-determined motives. In terms of extracurricular PA intentions, our findings were consistent with most previous studies [4,11,12], with boys being more likely to report intentions to undertake extracurricular PA in future. This finding is aligned also with the World Health Organization [28], which has documented that PA levels of males are higher levels than females, suggesting that boys have more intentions to undertake extracurricular PA than females in the following years.

Moreover, the results show that students who participated in out-of-school sport activities reported higher scores in autonomous motivation and intentions to undertake extracurricular PA in the future, although no differences were found in amotivation. Further researches are necessary to clarify this issue, because some prior studies [12] revealed that physically active students scored higher in autonomous motivation and intentions, and lower in amotivation, while other studies [15] found that participation in organized out-of-school sports was related to intentions but not to self-determined motivation, and other studies [14] found no differences between out-of-school sport participants and non-participants in either intentions or self-determined motivation. Our study however, indicated that autonomous motivation (but not amotivation) related (positively) to intentions to undertake extracurricular PA. It seems logical to think that students who practice sport after school time (they enjoy practicing sport) are involved in PE activities by self-determined motives, like enjoyment, and therefore, they have more extracurricular PA intentions in the following years.

4.4. Practical Implications

This study highlights the important role of supporting autonomy, competence, and relatedness satisfaction within PE classes. Examples of autonomy support strategies include teachers' taking perspective of their students' feelings, encouraging their active participation initiative taking, providing them choices and options, and transferring some freedom and responsibility to them when they perform in-class tasks [7]. With the aim of promoting competence satisfaction, PE teachers can adapt their teaching by offering tasks that are adjusted to the students' actual level of skills (balancing difficulty-capacity). Further, their feedback must focus on progress by providing task-focused (*r*ather than normative-based) feedback and by acknowledging their students' effort and improvement. Also, PE teachers should provide sufficient time to all students to they achieve the set objectives [7]. In order to promote relatedness satisfaction, PE teacher are recommended to use a warm and positive communication style; then need to encourage collaborative working, support and respect students' individuality, and behave in a friendly way. Additionally, PE teacher can use an all-inclusive strategy when groups are formed and promote role-playing or trust activities to improve all students' feeling of belongingness.

4.5. Limitations and Additional Future Directions

A limitation of this study is that controlled motivation was not included in the main analyses, while the learning environment was analyzed through students' perception about whether their teacher promoted autonomy, competence, and relatedness; so, these problems thereby using ratings from external observers [29]. Additionally, intentions were measured through a single item. Future studies could use broader scales in order to future intentions in more depth (i.e., sport modalities, frequency and intensity of activities, etc.). Further, the study used a cross-sectional methodology and it is observational in nature, so no causal relations can be claimed. It would be interesting if future studies employ a longitudinal design coupled with a quasi-experimental one would test the same hypotheses across time in an intervention versus in a control (i.e., no-treatment) group. Also, some potential cofounders like ethnicity, previous knowledge about PE or parents PA levels were not included, and they could affect the results. Additionally, these findings were found with this particular sample of Spanish students; so, conclusions are not applicable to all students. Lastly, future researchers may consider adding variables of the third level (teacher motivation, teacher need support, teacher need satisfaction, teacher burnout). In our case, this was not recommended due to the low group size of the highest level (n = 32).

5. Conclusions

As our study indicates, need satisfaction plays a key role in students' motivation. It seems that irrespective of gender or investing time and effort in sports, students who fulfill their needs for autonomy, competence, and relatedness in the PE class become more autonomous motivated (especially among males) and less amotivated (especially among females). PE teachers should not only support students' needs but also pay special attention to students who do not systematically participate in out-of-school sport activities and to females. For these groups, PE teachers need to maximize their students' basic psychological need satisfaction and eventually their autonomous motivation.

This study adds to the literature dealing with the interplay between PE learning environments and students' motivational processes and outcomes. It adds by showing that need supportive learning environments may perhaps not have uniform effects on students' quality of motivation but may vary depending, among other factors, on students' gender and need satisfaction. Given that a similar differential effect of need supportive environment was found on intentions to undertake extracurricular PA as a function of students' amotivation, the current study pinpoints the need for more research that will try to address the question of environmental fit: "Who benefits more (and under what circumstances)".

Author Contributions: Conceptualization, D.S.-O., A.M., and T.G.-C.; methodology, A.M. and F.M.L.; software, A.M.; validation, J.J.P., J.L.C., and F.M.L.; formal analysis, A.M.; investigation, D.S.-O. and T.G.-C.; data curation, D.S.-O. and J.L.C.; writing—original draft preparation, J.J.P., J.L.C., and F.M.L.; writing—review and editing, D.S.-O., J.J.P., J.L.C., and F.M.L.; visualization, all authors; supervision, T.G.-C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by FEDER, FSE and Govern of Extremadura, grant numbers GR18102 and TA18027.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Sport Education and Sportsmanship Orientations: An Intervention in High School Students

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Received: 12 December 2019; Accepted: 27 January 2020; Published: 29 January 2020

Abstract: One of the main goals for physical education is to develop the students' moral and ethical domain, where sportsmanship promotion is considered a key curricular component to tackle the achievement of this goal. This research aims to examine the influence of sport education on sportsmanship orientations in high school students. The participants were 148 (52.70% female; M_{age} = 17.04, SD_{age} = 0.99) high school students who were randomized into an experimental group (n = 74), which received 16 basketball lessons under sport education conditions, and a control group (n = 74), which received 16 basketball lessons following a traditional teaching approach. Pre-intervention and post-intervention measures on sportsmanship orientations were collected in both groups. A 2 (time: pre-test and post-test) x 2 (group: Sport Education and Traditional Teaching) multivariate analysis of variance test was performed on the five sportsmanship orientations. The results showed, for time x group interactions, the absence of significant multivariate effects in the level of the five sportsmanship orientations among both groups at pre-test (Pillai's trace = 0.06, p = 0.145). At post-test, significant multivariate effects were found in the level of each sportsmanship orientation between both groups in favor of the Sport Education group (Pillai's trace = 0.38, p < 0.001). Furthermore, regarding within-group pre-test to post-test differences, while there were nonsignificant multivariate effects (Pillai's trace = 0.03, p = 0.469) for the Traditional Teaching group; significant multivariate effects (Pillai's trace = 0.43, p < 0.001) were found for the Sport Education group, showing an increase in the level of respect for social conventions, respect for rules and referees, and full commitment and respect for opponents. There were also nonsignificant effects across gender (inter-group analysis: Pillai's trace = 0.08, p = 0.068; time x gender interaction: Pillai's trace = 0.03, p = 0.497) and after-school sports (inter-group analysis: Pillai's trace = 0.02, p = 0.776; time x after-school interaction: Pillai's trace = 0.01, p = 0.981). In conclusion, sport education is an effective pedagogical model to be taken into consideration by physical education teachers in order to optimally promote the high school student's moral and ethical education via the development of sportsmanship orientations in the context of school physical education.

Keywords: moral development; ethical development; fair play; sporting behavior; instructional models; models-based practice; skill-drill-game approaches; curriculum and instruction

1. Introduction

One of the main goals for high and middle secondary schools is to strengthen human rights as common values of a plural society, and, consequently, to prepare students for the effective exercise of citizenship in a democratic society [1]. On the basis of this, physical education (PE), due to its unique features with respect to interpersonal and social interactions among students in an open space, provides an optimal context for the development of these values [2]. To accomplish this goal, PE focuses on the development of the students' ethical and moral dimensions in general [3], which has been progressively specified in the display of sporting behaviors [4] measured through different indicators such as sportsmanship [5–7].

One of the most commonly used theories to analyze sportsmanship is the social and psychological view of sportsmanship outlined by Vallerand and colleagues [8,9]. According to this social and psychological perspective, sportsmanship is operationalized along five dimensions: (a) respect for social conventions, such as shaking hands with opponents after a match, acknowledgment of opponents' good performance, as well as being a good winner and loser; (b) respect for rules and referees, reflecting the player's concern and interest for complying with sport rules and obeying the decisions adopted by referees, even when they are not shared; (c) full commitment to one's sport, expressing the player's level in terms of effort, involvement, acknowledgment of failures and attempt to improve his/her skills; (d) respect for opponents, reflecting interest, concern and consideration toward the rival; (e) negative approach to sport, expressing the player's disruptive behaviors after making a mistake, as well as his/her participation conditioned by individual awards and trophies [9]. Consistent with the theoretical tenets proposed by Vallerand et al. [8], it is considered that players would generally behave in accord with their relative support for these five dimensions of sportsmanship, internalized through social interactions from the environment (i.e., coaches, peers, family, or PE teachers).

Several interventions in PE, aiming to enhance sportsmanship by means of traditional multi-activity units, have been promising as they suggested the possibility of improving the level of sportsmanship displayed by students. In particular, previous works reported an increase in the level of sportsmanship through the incorporation of fair-play dilemmas [10], discussion groups [11], or problem-solving activities [12]. Previous studies also showed to be effective when providing choice in instructional activities, using reproductive teaching styles, and requiring students to engage in cooperative activities [13].

At this point, sportsmanship promotion for students has currently become a predominant component for any national PE curriculum [14]. This consideration represents a challenge for PE teachers in the implementation of pedagogical models that can provide a response to fulfill this curricular demand [3]. One of the most extensively used model in the context of the school PE is sport education (SE) [15,16]. This models-based practice was designed to provide authentic, educationally-rich sports experiences for boys and girls in the context of the school PE [16], which makes it aligned with those more student-centered pedagogical models framed within the current zeitgeist of curriculum and instruction theory [17].

Siedentop, Hastie, and van der Mars [16] listed six non-negotiable features (i.e., seasons, affiliation, regular competition, culminating event, record keeping, and festivity) for SE. Particularly, students are permanently assigned to a team throughout a whole season for learning of a specific sport or curricular content. Teams compete during the season that begins with skills practice and team small-sided games and progresses by means of a series of formal competitions. The season finishes with a culminating event that is used to celebrate both individual and team achievements. As part of one team, each student performs a specific role associated with a series of responsibilities, and the team success will depend on the capacity of students to take the steps necessary to fulfill their roles, which can be in turn completed through "duty role" during the regular competition phase. Finally, SE offers students a festive experience during the culminating event and the end of the season awards celebration.

Through the implementation of these features, Siedentop [15] proposes that a student becomes a competent, literate, and enthusiastic sportsperson. This is to say, the student becomes an expert and competent player who understands and values sports and can distinguish between good and bad sportive practices. Consequently, students would participate and behave in a such way so as to converse, protect, and enhance sports cultures. Further, Siedentop [15] (p. 411) points that "SE should be understood as a process by which sport cultures might grow and prosper as humanizing influences for the lives of citizens".

Previous research on SE has widely shown its instructional benefits and positive educational implications for students in the context of the school PE [18–22]. Regarding works that have examined the influence of SE on sportsmanship in students, Hastie and Sharpe [23] discovered that the use of a fair play accounting system could develop responsibility and positive social behaviors in elementary school students. In a similar vein, Vidoni and Ward [24] informed that a SE season centered on sportsmanship improved active participation and diminished both the waiting time in instructional activities and off-task behaviors among middle school students. Furthermore, there was a slight enhancement in the number of on-task behaviors between the beginning and the end of the season. Likewise, Perlman and Karp [25] reported an increase of middle school students' level of autonomy, competence, and self-determined motivation after a SE season focused jointly on sportsmanship and inclusion.

On the other hand, both Ang and Penney [26] and Calderon, Martinez de Ojeda, Valverde, and Méndez-Giménez [27] indicated that a SE season enhanced sportsmanship displayed by elementary school students in general terms. In this same vein, Clarke and Quill [28] underlined that middle school students learnt the rules and acceptable codes of behavior for competition such as the recognition of success and the acceptance of defeat. Similarly, Sinelnikov and Hastie [29] discovered that a SE season evidently enhanced sportsmanship behaviors, although there was a certain confusion with its meaning for middle school students. More specifically, Brock and Hastie [30] reported that elementary school students' conception of sportsmanship changed as the season progressed. Specifically, students initially described sportsmanship as being polite, not arguing with referees, opponents or members of their own team, and equal participation among all members of the team. Nonetheless, when wining became more important as the season progressed, the students perceived it as the lower-skilled students receiving less game time in favor of those students perceived as higher-skilled. Furthermore, Wahl, Alexander, Sinelnikov, and Cuertner-Smith [31] showed that middle school students developed a stronger sense of sportsmanship after several consecutive SE seasons. Instead, García-López, Gutiérrez, González-Víllora, and Valero-Valenzuela [32] observed that a SE season reduced the number of antisocial and off-task behaviors in elementary school students. On the other hand, the work by Méndez-Giménez, Fernández-Rio and Méndez-Alonso [33] showed that a SE season, regardless of the use of self-made or conventional material, significantly improved the middle school students' level of respect for social conventions, respect for rules and referees, and respect for opponents in middle school students. Despite that this work was based on the social and psychological view for sportsmanship proposed by Vallerand et al. [8,9], it did not take into account the measure of two of the five orientations (i.e., full commitment and negative approach) that conceptualize sportsmanship. Therefore, its analysis continues to be uncompleted.

In addition, it should be highlighted that the absence of a widespread agreement regarding the conceptualization of sportsmanship [6,34] has likely hampered a solid understanding of how the curricular scaffold of SE could influence the development of students' sportsmanship in the context of the school PE. Indeed, most of the studies on SE have considered the use of unclear theoretical frameworks for the analysis of sportsmanship. This fact does not allow one to draw solid conclusions about the real impact of the curricular scaffold of SE on the development of sportsmanship given that its conceptualization does not only raised problems of understanding for students but it also varied from one research to another, making it impossible its comparison. On the other hand, to date, there has been no evidence from studies on the influence of SE on sportsmanship among high school students. Thus, it should be considered that the students of this educational stage are characterized by a high level of maturity, abstract thinking, responsibility or autonomy, such that their instructional needs are different from those required by students of previous educational stages [35]. Because of these differences, SE is thought to may have a distinct effect in high school students since the features defining this pedagogical model seem to fit best the instructional needs of this type of student.

Therefore, the objective of this research is to examine the influence of a SE intervention program on the five sportsmanship orientations proposed by Vallerand et al. [8,9] in a sample of high school students in PE. Following the results found in previous studies [26,28,30,33], we hypothesized that a SE intervention would significantly improve the level of social conventions, respect for rules and referees, full commitment and respect for opponents, and it would significantly diminish the level of negative approach in high school students. Moreover, we also hypothesize that a traditional teaching (TT) intervention would keep the same level of each one of the five sportsmanship orientations among high school students in PE.

2. Materials and Methods

2.1. Participants and Setting

The participants were 148 high school students (70 boys and 78 girls) aged between 16 and 18 years (M_{age} = 17.04, SD_{age} = 0.99) from six different PE classrooms in three public high secondary schools located in a city in south-eastern Spain. Regarding their educational background, all students tackled basketball as curricular content in previous academic years through skill-drill-game approaches (also known as traditional teaching, TT); however, none of them was previously instructed under SE conditions. With respect to extracurricular sport, 99 students (50 boys and 49 girls) claimed to practice after-school sport, with a weekly frequency ranging from 1 to 6 days ($M_{frequency}$ = 3.53, $SD_{frequency}$ = 1.28). Concerning their ethnic background, 16 (10.81%) students self-reported belonging to ethnic minority communities.

In addition, six (four male and two female) PE in-service teachers took part in this study. All of them claimed to have obtained Bachelors of Science in PE and Sports together with Professional Masters of Education (post-primary PE). Additionally, they self-reported a teaching experience between 5 and 16 years ($M_{experience}$ = 11.98, $SD_{experience}$ = 3.99) and, more specifically, they claimed to have implemented both skill-drill-game approaches and SE. In this sense, all of them self-reported experience with SE of at least two academic years. The three public schools were selected in accordance with their previous collaboration with the research team in prior studies. These three schools share similar social, cultural, and economic contexts and are in the same urban area.

2.2. Design and Procedure

Following previous research on SE [36–39], this study adopted a clustered randomized approach with, a priori, a non-equivalent control group and with pre-intervention and post-intervention measures. Due to each one of the three participating schools having already organized all their high school students into two classrooms, it was impossible to randomize them in accordance with an independent variable (pedagogical models). Thus, the two participating classrooms from each school were randomized depending on the two pedagogical models considered in this study, such that a classroom was randomly selected as an experimental or SE group, while the second classroom was consequently assigned as a control or TT group. In this regard, a total of 74 high school students formed the experimental or SE group, while another 74 high school students comprised the control or TT group.

On the other hand, the data collection process was conducted at the beginning and end of the intervention program through a questionnaire measuring the current perception of sportsmanship orientations displayed by the high school students in each time. The questionnaire administration was carried out by the researchers, who explained to the students that their participation was voluntary and anonymous, in addition to emphasizing the absence of valid or incorrect responses given that only their opinion was to be known. Furthermore, the research team was available for the survey respondents to resolve any type of doubt raised during the data collection process. The administration of the questionnaire took place in a classroom environment with an approximate time of 15 mins.

This research was approved by the Ethics Committee on Human Research of the corresponding University (322/CEIH/2017). In addition, the permissions of the three high secondary schools participating and informed consent from the student's parents or legal guardians are available.

2.3. Intervention Program

Prior to the beginning of the intervention program, the research team held three different meetings with the three PE teachers responsible for the intervention under SE conditions in order to establish the objectives, contents, and instructional activities to be taught in each lesson. This same procedure was also followed for the three PE teachers in charge of the intervention under TT conditions. The six PE teachers unanimously agreed to select basketball as the sport to be taught.

2.3.1. Sport Education Program

The basketball SE unit included sixteen 60-min lessons, twice per week for a period of eight weeks in the regular PE schedule. The SE season was composed of three main phases. Specifically, the initial phase was formed by an introductory lesson and a teacher-directed practice sub-phase. In the initial lesson, the teacher introduced the key features of SE, while a student committee, chosen by the students and under the supervision of the teacher, created the teams. It was agreed that each team would be composed of a balanced number of lower-, average- and higher-skilled players, a similar number of boys and girls, and expert basketball players. Once the teams were built, the students also designated the different roles established (main coach, physical trainer, material manager, sports analyst and referee) to each member of their team, in addition to choosing the color of clothes, shield and slogan as distinctive signs of each of the distinct teams created. The teacher-directed practice sub-phase, the second and third lessons, aimed to familiarize the students with the curricular scaffolding structure proposed for this pedagogical model and to develop technical skills and tactical awareness of basketball.

The autonomous practice phase included the fourth to twelfth lessons and was directed by the students. This phase aimed to develop the technical and tactical skills for which team practice and competition were combined. The lesson was structured into (a) a 10-min warm-up led by the physical trainer of each team; (b) a 40-min main-part lead by the main coach, in which modified and small-sided games and a preseason tournament were conducted; and (c) a 5-min cool-down, focused on the reflections of the group related to fair-play dilemmas, responsibility, and team goals, and stretching exercises. Furthermore, the "duty role", along with the fair-play accounting system, was started during the preseason tournament and was maintained until the end of the season. Regarding the fair-play accounting system, all the teams began the preseason tournament with 10 play-fair points. They could score two points for winning, one for defeat and five fair-play points for each fault-free competition. However, they could lose one point every time a determined team member violated the game rules and three points each time the fair-play rules were broken. These rules of fair play were agreed between the teacher and students at the beginning of this phase. On the other hand, the teacher adopted a role of guide in this phase, more specifically, he/she met the coaches just before the beginning of each lesson in order to tackle the problems found in the prior lesson, explaining briefly the lesson to be taught and supporting his/her instruction and leadership. In addition, the teacher also moved around on the basketball courts, providing each team with general feedback and informing the coach on mistakes for him/her to provide his/her team with specific feedback.

The final phase included a regular competition sub-phase and a culminating event. In the regular competition sub-phase—the 13th, 14th, and 15th lessons—a formal tournament among all the teams was developed. For this end, the lesson was structured into (a) a 10-min warm-up led by the physical trainer; (b) a 30-min main part, in which the different competitions were played; (c) a 10-min phase for the elaboration of reports; and (d) a 5-min cool-down. In the latest lesson of the season, a culminating event took place to decide the ranking of the teams participating and an awards ceremony was held to reward all efforts and accomplishments made by the students, where the teacher was the master of ceremony.

2.3.2. Traditional Teaching Program

The basketball unit was implemented under a skill-drill-game approach format, consisting of sixteen 60-min lessons, twice per week over a period of eight weeks in regular PE schedule. The first 12 lessons focused specifically on basic technical basketball skills and its basic tactical elements. These lessons were organized into (a) a 10-min warm-up; (b) a 40-min main part, consisting of a first phase with tasks centered mainly on the development of basic technical skills, a second phase centered on modified and small-sided games among teams, and a third phase centered on competitions; and (c) a 5-min cool-down, through stretching exercises. The latest four lessons focused on competition, where the teacher randomly formed the different teams for each of the four lessons, refereed the competitions, and moved around on the basket courts in order to check the degree of compliance with the game rules. Throughout all the lessons, the teacher controlled for instructional interactions, activity presentation and structure, time management, and feedback.

2.3.3. Model Fidelity

As the PE teachers had manifested their previous experience with both pedagogical models, a brief 10-hour training course was carried out to emphasize the key features defining SE and TT, respectively. This course relied on the guidelines outlined by Sinelnikov [40] and Calderon and Martínez de Ojeda [41]. In addition to this training course, the three PE teachers responsible for SE were monitored by a researcher with wide expertise in this models-based practice, while the other three PE teachers in charge of TT were monitored by a second researcher with broad expertise in this pedagogical model. Particularly, this monitoring included three action units: (a) analysis lesson-per-lesson throughout the intervention program, (b) meetings just after each lesson to solve problems and doubts, and (c) an external assessment conducted by a single observer for each group [39,42,43]. In particular, the observation record sheet elaborated by Sinelnikov [40], and adapted by Calderon, Martinez de Ojeda and Hastie [43] to the Spanish context, was used to verify the correct implementation of SE in the experimental group, while the observation record sheet developed by Cuevas, García-López and Serra-Olivares [39] in the Spanish context was used to confirm the adequate implementation of TT in the control group. Both assessors also ensured the absence of mismatches between the planned and implemented content in the two instructional conditions.

2.4. Measurements

Sportsmanship Orientations

The Spanish version [44] of the Multidimensional Sportsmanship Orientations Scale [9] was used to measure sportsmanship orientations in PE. This instrument consists of 25 items grouped into 5 items per factor to assess respect for social conventions (e.g., "Always shake hands after the game"), respect for rules and referees (e.g., "Do not criticize the referee for mistakes against self"), full commitment (e.g., "Maximum effort in practices and games"), respect for opponents (e.g., "Refuse to take an advantage of an injured opponent") and negative approach (e.g., "Ridicule a less competent opponent"). Each item is measured on a 5-point Likert-type scale, from 1 (does not correspond at all to me) to 5 (corresponds exactly to me).

2.5. Data Analysis

The Statistical Package for Social Sciences (IBM SPSS Statistics for Mac, version 25.0; Armonk, NY, USA) was used to analyze statistical data. Table 1 shows absolute and standardized values below 1.96 for the skewness and kurtosis coefficients [45], suggesting that the assumption of normality cannot be rejected. Descriptive statistics (mean and standard deviation) were calculated for each dependent variable. Additionally, descriptive statistics and the percentage of agreement, neutrality and disagreement were also calculated for each of the 25 items. For this estimation, we considered the points four and five as representative of agreement, the point three as a neutral value, while the points one and two as indicative of disagreement. The Cronbach's alpha coefficient (α), which is acceptable with values over 0.70 [46], was estimated to inspect the reliability of all dependent variables. A 2 (time: pre-test and post-test) x 2 (group: SE and TT) multivariate analysis of variance (MANOVA) test was performed to examine the possible effect of the two instructional conditions (SE and TT) on each dependent variable. In this analysis, gender and after-school sports were introduced as covariates.

Prior to 2 x 2 MANOVA, there was the need to analyze the homogeneity of covariances through Box's test [45]. The results (Box's $M = 124.15$, F [55, 68835.98] = 2.09, $p < 0.001$) indicated the violation of the assumption of homogeneity of covariances, suggesting the use of Pillai's trace as a test statistic for the multivariate analysis [45]. Effect size was also calculated in terms of partial eta squared. According to the criterion proposed by Field [45], a small effect size is considered to be with values as high as 0.10, medium with values close to 0.25, and large with values equal to 0.50 or higher. The level of statistical significance was set at $p \leq 0.05$.

Table 1. Main features for the implementation of sports education and traditional teaching.

Pedagogical Model	Duration	Student's Role	Competition Phase	Groups/Team
Sport Education	15 60-min lessons	Active involvement in the decision-making process Autonomous fulfillment of responsibilities	Fair play accounting system Duty role team A formal schedule of competition Record keeping and publicity of results	Created by a selection committee Constant throughout the season Heterogeneous, but balanced teams
Traditional Teaching	15 60-min lessons	Compliance with the instructions provided by the teacher	The teacher refereed the matches and managed the fair play	Created by the teacher Changing throughout the season Heterogeneous teams

3. Results

Table 2 shows Cronbach's alpha values above 0.70 for all the dependent variables considered, except for the negative approach dimension [46]. Overall, these findings implied an adequate level of reliability for each sportsmanship orientation. Table 2 also displays differences in the mean score for all the dependent variables between pre-test and post-test for both instructional conditions. More particularly, Table 3 shows mean scores along with the percentage of agreement, neutrality, and disagreement perceived by the students for the total of items for the SE and TT groups at pre-test and post-test.

Table 2. Descriptive statistics and reliability coefficients for the Sport Education and Traditional Teaching Groups.

	Sport Education (n = 74)										**Traditional Teaching (n = 74)**									
	Pre-Test					**Post-Test**					**Pre-Test**					**Post-Test**				
	α	M	SD	γ_1	γ_2	α	M	SD	γ_1	γ_2	α	M	SD	γ_1	γ_2	α	M	SD	γ_1	γ_2
R. social conventions	0.79	3.24	0.66	−0.24	−0.55	0.84	4.01	0.72	−0.41	−0.60	0.74	3.05	0.76	−0.25	0.46	0.82	3.10	0.65	−0.24	−0.42
R. rules and referees	0.73	3.66	0.59	−0.47	−0.56	0.77	4.24	0.60	−0.50	−0.38	0.76	3.68	0.51	−0.66	0.58	0.81	3.78	0.54	−0.35	−0.39
Full commitment	0.72	3.28	0.61	−0.69	0.52	0.77	4.14	0.60	−0.14	−1.08	0.76	3.38	0.70	−1.13	1.77	0.78	3.33	064	−0.48	−0.03
R. opponent	0.72	3.35	0.60	−0.09	−0.04	0.72	3.78	0.66	−0.33	−0.30	0.78	3.37	0.67	−0.81	0.92	0.76	3.38	0.73	−1.36	1.40
Negative approach	0.66	2.56	0.68	0.36	−0.29	0.65	2.54	0.84	0.29	−0.78	0.64	2.51	0.52	0.14	−0.55	0.67	2.62	0.67	0.34	−0.70

Note: R = Respect for; α = Cronbach's alpha coefficient; γ_1 = Standardized skewness coefficient; γ_2 = Standardized kurtosis coefficient.

Table 3. Descriptive statistics for each item according to the Sport Education and Traditional Teaching groups.

	Sport Education (n = 74)										**Traditional Teaching (n = 74)**									
	Pre-Test					**Post-Test**					**Pre-Test**					**Post-Test**				
	M	**SD**	**%A**	**%N**	**%D**	**M**	**SD**	**%A**	**%N**	**%D**	**M**	**SD**	**%A**	**%N**	**%D**	**M**	**SD**	**%A**	**%N**	**%D**
Respect for social conventions																				
Item 1	3.44	0.81	20.30	78.30	1.40	4.05	0.94	74.30	20.30	5.40	2.89	1.07	16.20	44.60	39.20	3.11	1.03	16.20	75.70	8.10
Item 6	3.29	0.91	23.00	71.60	5.40	4.16	0.83	76.30	21.00	2.70	3.01	1.05	48.60	41.90	9.50	3.11	0.91	20.30	75.70	4.10
Item 11	3.07	1.13	20.30	67.50	12.20	4.00	0.74	75.60	23.00	1.40	2.88	0.98	10.80	48.60	40.60	3.03	0.87	32.40	62.20	5.40
Item 16	3.18	1.05	29.70	63.50	6.80	3.91	0.81	71.60	25.70	2.70	3.31	0.82	32.40	63.50	4.10	3.10	0.88	20.30	75.60	4.10
Item 21	3.21	0.97	25.70	68.90	5.40	3.93	0.93	66.20	29.70	4.10	3.16	1.05	6.80	48.70	44.60	3.10	0.93	28.40	67.50	4.10
Respect for rules and referees																				
Item 2	3.75	0.85	17.60	81.00	1.40	4.42	0.70	87.80	12.20	0.00	3.88	0.72	43.30	43.20	13.50	3.93	0.68	37.80	51.40	10.80
Item 7	3.89	0.72	10.80	87.80	1.40	4.43	0.73	91.90	5.40	2.70	3.91	0.67	35.10	55.40	9.50	3.91	0.73	39.50	57.80	2.70
Item 12	3.76	0.75	9.50	87.80	2.70	4.30	0.81	83.80	13.50	2.70	3.68	0.77	12.20	90.50	2.70	3.87	0.71	35.40	61.90	2.70
Item 17	3.03	0.99	36.50	51.30	12.20	3.62	1.19	56.80	27.00	16.20	2.95	0.98	18.90	51.40	29.70	3.13	1.15	31.10	54.00	14.90
Item 22	3.85	0.75	12.20	86.40	1.40	4.39	0.83	90.80	5.40	4.10	3.99	0.69	24.30	64.90	10.80	3.94	0.74	26.80	70.50	2.70
Full commitment																				
Item 3	3.37	0.87	16.20	81.10	2.70	4.27	0.76	86.50	10.80	2.70	3.50	0.91	17.60	77.00	5.40	3.33	0.86	14.90	81.00	4.10
Item 8	3.25	0.93	17.60	78.30	4.10	4.12	0.84	78.30	17.60	4.10	3.31	0.92	21.60	73.00	5.40	3.37	0.85	17.60	78.30	4.10
Item 13	3.22	0.93	18.90	74.30	6.80	4.12	0.75	79.70	18.90	1.40	3.28	0.95	21.60	70.30	8.10	3.37	0.82	14.90	81.00	4.10
Item 18	3.30	0.89	20.30	77.00	2.70	4.13	0.94	74.30	21.60	4.10	3.62	1.05	10.80	82.40	6.80	3.31	1.02	23.00	71.60	5.40
Item 23	3.30	0.76	17.60	81.00	1.40	4.04	0.94	79.70	13.50	6.80	3.20	0.95	21.60	71.60	6.80	3.30	0.93	14.90	79.70	5.40
Respect for opponents																				
Item 4	3.74	0.87	21.60	75.70	2.70	4.20	0.86	79.70	16.20	4.10	3.78	1.06	16.20	75.70	8.10	3.81	0.99	90.50	14.90	5.40
Item 9	3.76	0.84	18.90	78.40	2.70	4.20	0.86	78.30	20.30	1.40	3.94	0.94	12.20	83.70	4.10	3.75	0.91	78.30	17.60	4.10
Item 14	2.98	0.94	48.60	40.60	10.80	3.41	1.08	47.30	36.50	16.20	3.01	1.16	31.10	50.00	18.90	3.09	1.06	46.00	35.10	18.90
Item 19	3.06	1.00	37.80	51.40	10.80	3.64	1.22	60.80	21.60	17.60	3.24	0.98	41.90	51.30	6.80	3.12	1.14	52.70	28.40	18.90
Item 24	3.21	1.13	33.80	52.70	13.50	3.45	1.27	50.00	29.70	20.30	2.90	1.39	24.30	47.30	28.40	3.12	1.34	51.40	27.00	21.60
Negative approach																				
Item 5	3.99	0.87	75.70	21.60	2.70	3.65	0.94	72.90	20.30	6.80	3.95	0.95	64.80	31.10	4.10	4.09	0.86	77.00	20.30	2.70
Item 10	2.03	1.11	12.20	18.90	68.90	2.20	1.34	25.60	20.30	54.10	2.15	1.03	12.20	24.30	63.50	2.24	1.23	20.20	12.20	67.60
Item 15	2.52	1.18	24.40	32.40	43.20	2.42	1.31	29.80	25.70	44.60	2.61	1.23	23.00	29.70	47.30	2.77	1.21	32.40	23.00	44.60
Item 20	2.03	1.16	12.50	17.60	68.90	2.44	1.49	33.80	21.60	44.60	2.07	1.15	12.20	16.20	71.60	2.50	1.32	28.40	13.50	58.10
Item 25	2.21	1.17	16.30	25.70	58.10	2.01	1.29	19.00	20.20	60.80	1.77	0.98	6.70	14.90	78.40	2.24	1.18	17.50	23.00	59.50

Note: %A = percentage of agreement; %N = percentage of neutrality; %D = percentage of disagreement.

A 2 x 2 MANOVA test was performed to examine the effects of time (pre-test and post-test) and group (SE and TT) on each one of the five sportsmanship orientations. Nonsignificant multivariate effects were found either for the gender covariate (inter-group analysis: Pillai's trace = 0.08, F (5.00, 140.00) = 2.25, p = 0.068, η^2_p = 0.07; time x gender interaction: Pillai's trace = 0.03, F (5.00, 140.00) = 0.88, p = 0.497, η^2_p= 0.03) or the after-school sport covariate (inter-group analysis: Pillai's trace = 0.02, F (5.00, 140.00) = 0.50, p = 0.776, η^2_p = 0.02; time x after-school interaction: Pillai's trace = 0.01, F (5.00, 140.00) = 0.14, p = 0.981, η^2_p = 0.01).

With respect to time x group interactions, Table 4 shows nonsignificant multivariate effects in the level of the five sportsmanship orientations among both groups at pre-test (Pillai's trace = 0.06, F (5.00, 140.00) = 1.67, p = 0.145, η^2_{p} = 0.06), indicating the homogeneity of all dependent variables at the beginning of the intervention program between the SE and TT groups. At post-test, significant multivariate effects (Pillai's trace = 0.38, F (5.00, 140.00) = 16.92, p < 0.001, η^2_p = 0.38) were found in the level of the five sportsmanship orientations among the two groups. There was a statistically significant increase in the level of respect for social conventions, respect for rules and referees, full commitment, and respect for opponents.

Table 4. Analysis of mean differences between the Sport Education and Traditional Teaching groups (pre-test and post-test) for sportsmanship orientations.

Time	Groups	Variable	*Mdif (SE)*	*p*-Value
Pre-test	SE-TT	Social conventions	0.17 (0.12)	0.151
		Respect for rules and referees	−0.04 (0.09)	0.703
		Full commitment	−0.13 (0.11)	0.220
		Respect for opponents	−0.04 (0.10)	0.674
		Negative approach	0.06 (0.10)	0.578
Post-test	SE-TT	Social conventions	0.89 (0.11)	>0.001
		Respect for rules and referees	0.45 (0.09)	>0.001
		Full commitment	0.81 (0.10)	>0.001
		Respect for opponents	0.39 (0.12)	0.001
		Negative approach	−0.10 (0.13)	0.442

Note: SE = sport education; TT = traditional teaching; *Mdif* = mean difference; *SE* = standardized error.

In relation to within-group pre-test to post-test differences, Table 5 displays a nonsignificant multivariate effect for the TT group (Pillai's trace = 0.03, F (5.00, 140.00) = 0.92, p = 0.469, η^2_{p} = 0.03) in the level of the five dependent variables between pre-test and post-test. Instead, a significant multivariate effect was found for the SE group (Pillai's trace = 0.43, F (5.00, 140.00) = 21.10, p < 0.001, η^2_{p} = 0.43) between pre-test and post-test. Specifically, there was a statistically significant increase in the level of respect for social conventions, respect for rules and referees, full commitment, and respect for opponents.

Table 5. Analysis within-group pre-test to post-test differences in sportsmanship orientation scores.

Time	Group	Variable	*Mdif (SE)*	*p*-Value
Pre-test to Post-test	Sport Education	Social conventions	0.77 (0.12)	<0.001
		Respect for rules and referees	0.58 (0.10)	<0.001
		Full commitment	0.89 (0.11)	<0.001
		Respect for opponents	0.44 (0.11)	<0.001
		Negative approach	0.04 (0.11)	0.748
	Traditional Teaching	Social conventions	0.04 (0.12)	0.721
		Respect for rules and referees	0.10 (0.10)	0.335
		Full commitment	0.05 (0.11)	0.632
		Respect for opponents	0.01 (0.11)	0.912
		Negative approach	0.12 (0.11)	0.261

Note: *Mdif* = mean difference; *SE* = standardized error.

4. Discussion

The objective of this research was to analyze the influence of SE on the five sportsmanship orientations outlined by Vallerand et al. [8,9] in a sample of high school students during their sports teaching and learning process in the context of school PE. The results revealed that a SE season significantly improved the level of respect for social conventions, respect for rules and referees, full commitment, and respect for opponents, but not the level of negative approach displayed by high school physical education students.

The results emerging from this work showed that a SE season significantly increased the level of respect for social conventions among high school students, supporting one of the hypotheses raised for this study. These findings are also consistent with the results obtained by Méndez-Giménez et al. [33], who reported an increase in middle school students' perception of respect for social conventions after a SE season, regardless of the use self-made or conventional materials. Furthermore, these results are also in line with those found by Brock and Hastie [30] to the extent that they discovered that middle school students were polite by displaying behaviors such as shaking hands with opponents and acknowledging opponents' good performance.

A second finding from this work revealed a significant enhancement in the level of respect for rules and referees after a SE season in high school students. On the one hand, these results are in contrast to the findings obtained by Brock and Hastie [30] and Wahl-Alexander et al. [31]. Both studies discovered certain conflicts with respect to the compliance with the rules by determined teams whose members did not exemplify fair-play behaviors given that they attributed a higher relevance to winning as the season progressed. In this regard, Wahl-Alexander et al. [31] emphasized that the agreed nature in the setting of the rules of the game between teacher and students could likely have propitiated some type of breach by determined students with a higher social status. On the other hand, the findings of this research are aligned with those obtained by Méndez-Giménez et al. [33] in the direction that they also reported an improvement in respect for rules after a SE season.

In relation to respect for referees, the results of the present study differed from those reported by Wahl-Alexander et al. [31] in the sense that they highlighted the existence of discrepancies with referees for their dishonest decisions adopted during competitions by middle school students. Conversely, the findings emerging from the current study are delineated with those obtained in previous research [29,30]. Specifically, Brock and Hastie [30], together with Sinelnikov and Hastie [29], stated that middle school students were polite in accepting the referee's decisions throughout the SE season. These results referred to the increase in respect for referees would be explained by each student having adopted the role of referee over the course of the SE season. Moreover, previous research pointed out that there were positive responses by students in officiating tasks, as well as higher engagement towards this role [47], given that students were worried about the serious and diligent performance of this role in order to avoid conferring advantages to a specific team [29].

A third result derived from this research reflected that a SE season significantly enhanced full commitment in high school students, which underpinned one of the hypotheses posed for this work. These findings are in line with those obtained by Calderon, Martínez de Ojeda, and Hastie [48] and Layne and Hastie [17]. A possible justification would be supported by students during the SE season having the opportunity to experience a higher level of autonomy in their teaching and learning process, fulfilling one of the main instructional needs demanded by students for the educational stage of high school [35]. In this regard, each group of students had the possibility to create their own warm-up session and to develop the instructional activities at their own pace, which probably led to an increase in students' intrinsic desire to actively participate in PE class [39,42].

In this same vein, autonomy-supporting environments characterizing SE [49,50] facilitate students taking the initiative to engage actively in the different activities developed during the season and, in turn, displaying their ability to successfully complete each task raised. In addition to the increase in the amount of student commitment [17,48], previous research has also indicated gains in the quality of this commitment [42]. In other words, the student's commitment evolved from a commitment initially based on external contingencies (e.g., to achieve the approval of all members of the team) to one based on the identification of the benefits associated with this pedagogical model (e.g., cooperation, workgroup, or autonomy) [42].

The fourth finding of this study showed a significant gain in the high school students' level of respect for opponents, supporting one of the hypotheses of the present work. The results are consistent with the results obtained by Méndez-Giménez et al. [33] and Brock and Hastie [30] in the sense that both studies discovered that the students helped other classmates and were friendly with each of them. This fact may be explained by the curricular scaffold of SE promoting a task-involving climate [51] that mainly favors both personal effort and learning and mastery of new skills, contributing to improving the level of cohesion and relationship among students, regardless of whether they are opponents or teammates [38,42]. This would be possible because the success perceived by students in a SE season rests on their personal progress and self-referred evaluation criteria instead of focusing on the comparison of the student's capacity with the remaining classmates [42,51]. Furthermore, these personal achievements are markedly highlighted in the culminating event by means of the awards ceremony and the festival atmosphere that involves the season under SE conditions [15].

The fifth result did not endorse one of the hypotheses proposed for the present research since there were nonsignificant changes in the level of negative approach after a SE season for high school students. Conversely, there was a slight increase that did not reach the level of statistical significance, making us suggest that the competitive aspects of the SE season could likely have a more marked nuance for certain students, encouraging them to develop determined negative social behaviors [15,32]. Possibly the curricular scaffold of SE partly generated these negative social behaviors, given that the inequality between boys and girls could be accentuated due to boys assuming a higher profile than girls in the most decisive moments of the season through the completion of a greater number of responsibilities and the desire to take the roles perceived as the most important ones [52].

However, it should be noted that the five orientations proposed by Vallerand [8,9] are inter-correlated, as they attempt to conceptualize sportsmanship. In this regard, respect for social conventions, respect for rules and referees, full commitment, and respect for opponents would refer to good sportive practices in the sense that all of them represent behaviors related to shaking hands with opponents after a competition, acknowledging both their good performance and the own failures, displaying interest and concern for the opponents, as well as, complying with the rules and obeying the decisions adopted by referees. In contrast to these good sportive behaviors, there would also be bad sportive practices such as disruptive behaviors after a failure or participation based on obtaining some type of award, reflecting the concept proposed for negative approach. Additionally, it should be emphasized that the relationships among the five sportsmanship orientations are not orthogonal in its nature; this is to say, the increase in the level of a specific sportsmanship orientation (e.g., respect for rules and referees) would not necessarily mean a gain in a second sportsmanship orientation (e.g., respect for social conventions) or a decrease in a third sportsmanship orientation (e.g., negative approach). Thus, the curricular scaffold of SE has fostered the social and interpersonal interactions between teacher and students, promoting the process of internalization of those good sportive practices (i.e., respect for social conventions, respect for rules and referees, full commitment, or respect for opponents) in high school students, making them behave throughout the season in accordance with their relative support for the five sportsmanship orientations [8,9]. Nonetheless, it should be emphasized that the use of a fair play accounting system could imply that the high school students adopted any good sportive practice to serve their own needs. In other words, the students could follow the goal of their compliance not only to "do the right thing" based on moral and ethical principles, but also to do what they had to do to win, which was to obtain a large number of fair play points. In this sense, the role of the fair play accounting system needs to be deeply examined in future studies.

Despite the results obtained, this research has presented a series of limitations that should be considered. Firstly, the use of an intentional sampling method leads us to cautiously interpret the findings, making it necessary for new studies to confirm or discuss the results emerging from this research. Secondly, the external assessment was carried out by a single researcher in each group in accordance with the guidelines proposed in previous studies to ensure the fidelity of both pedagogical models [39,42,43]. Nonetheless, this could compromise the verification of the correct implementation of the key features defining both pedagogical models. In this way, the use of at least two external researchers is recommended to allow one to estimate the degree of agreement between external assessors with respect to the observed actions. Thirdly, the results referring to the negative approach dimension should be circumspectly interpreted due to its marginal Cronbach's alpha value obtained in this study, which has been previously detected [44,53]. Fourthly, this work considered basketball as the curricular content to be taught, despite that the participating students had already addressed it in previous educational levels. Thus, future studies are needed to use new curricular contents for students in order to examine more accurately the effect of SE on sportsmanship orientations in high school students. Fifthly, this study was developed in the educational stage of high school; therefore, future studies are required to analyze the effect of SE on the five sportsmanship orientations described by Vallerand et al. [8,9] in students from other educational stages (e.g., elementary school, middle school, or higher education). Sixthly, this research has only examined the impact of SE at the beginning and the end of the intervention program, not analyzing the target-dependent variables in each of the three main phases described for SE. Thus, future works should take into account this consideration in order to deeply study in which moment of the season the students internalize each of the five sportsmanship orientations proposed by Vallerand et al. [8,9].

5. Conclusions

The results of this research reflect the significant improvement of four of the five sportsmanship orientations (i.e., respect for social conventions, respect for rules and referees, full commitment, and respect for opponents) outlined by Vallerand et al. [8,9] after a SE season. These results would imply that SE may be considered as an optimal pedagogical model to be used by PE teachers in order to fulfill high school curricular demands with respect to sportsmanship promotion as an essential part of student moral and ethical development [14]. Likewise, PE teachers should take into consideration the use of SE as a pedagogical model with the capacity to develop in high school students the skills needed to value sports and discern between good and bad sportive practices through the development of sportsmanship with the ultimate goal to conserve, protect, and enhance sports cultures, and, consequently, to educate students as citizens to take active part in a plural and democratic society [1,14].

Author Contributions: All authors have read and agree to the published version of the manuscript. Conceptualization, R.B. and J.M.-C.; Methodology, R.B. and J.M.-C.; Formal analysis, R.B.; Investigation, R.B. and J.M.-C.; Resources, J.M.-C. and R.B.; Data curation, R.B.; Writing—Original draft preparation, R.B.; Writing—Review and editing, J.M.-C. and R.B.; Project administration, J.M.-C.; Funding acquisition, J.M.-C.

Funding: This research was funded by the Junta de Andalucía, PIV: 043/08.

Acknowledgments: A special thanks to all the students and Physical Education teachers who participated in this research. We would also like to thank Belén Cueto, José Macarro-Moreno and Esther Morales for their recommendations and suggestions in drafting the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

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Article

Functional Ability, Frailty and Risk of Falls in the Elderly: Relations with Autonomy in Daily Living

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Received: 4 December 2019; Accepted: 2 February 2020; Published: 5 February 2020

Abstract: The objective of this research was to determine the differences in autonomy in both basic activities of daily life in instrumental activities of daily life, as well as functional capacity, fragility and risk of falls between an active group and a sedentary group. The individual associations of functional capacity, fragility and risk of falls were also analyzed, with autonomy in basic activities of daily living and in instrumental activities of daily living in the active group. In this cross-sectional investigation, 139 people from Huelva between 65 and 87 years of age were evaluated (Mean (M) = 73.1; standard deviation (SD) = 5.86); 100 were women and 39 men. The active and sedentary group were composed of 69 and 70 elderly people, respectively. The active group carried out a physical activity program. Among the results, a significant effect was seen in the multivariate contrast of the study variables, $V = 0.24$, $F\ (5, 137) = 8.58$, and $p < 0.001$; while in the linear regressions in the active group, the Vivifrail with the Barthel Index (Δ Adj. $R^2 = 0.15$) and with the Lawton and Brody Scale (Δ Adj. $R^2 = 0.22$) were used. In conclusion, the active group presented better values in all the variables evaluated in comparison to the sedentary group, establishing statistically significant differences. In addition, in the active group, it has been found that functional capacity is a significant predictive variable of autonomy in instrumental activities of daily living (22%), while fragility and the risk of falls are significant predictors of autonomy in activities of basic daily life (15%).

Keywords: older people; quality of life; exercise; prevention; falls

1. Introduction

Currently, the ageing demographic plays a large role in developed societies [1] and are becoming a highly relevant social and political challenge [2]. This demographic change has occurred due to a decrease in birth rate and in mortality and in morbidity, and an increase in life expectancy [3].

In Europe, the latest Eurostat data places the population over 65 as 19.7% of the total population. It is expected that by 2050, this will reach 30%. There is also significant feminization of old age, as there are double the number of women compared to men at 85 years of age.

According to the National Statistical Institute mortality tables, the life expectancy at birth of Spanish women is 87.7 years, and that of men is 80.4 years (the highest in Europe) [3,4].

Given the importance and social impact that this continuous increase of older people in Spain is having, this population group is being studied to better understand the ageing process and guarantee the health and quality of life of older people [5–7].

Ageing involves changing and acquiring knowledge and experiences that need adaptation and development at a personal and social level [1]. In this process, there are changes that worsen the state of health and physical fitness, causing a deterioration of organic functions such as physical, psychological and social functionality [1,8,9]. Ageing is not determined just by biological factors, but also by psychological, social and ecological factors, so whether this ageing is effective will depend on the ability of each person to adapt to the changes that occur, since this adaptation is a protective factor in the face of physical, mental and emotional decline [1,10].

The key is not just to age in any old way, but to do so in the best state of health by following a healthy lifestyle and participating in multiple activities [1,11]. Health is defined as the complete state of physical, mental and social well-being, not merely as the absence of disease—this is the fundamental basis for a population's quality of life [12]. Healthy ageing looks beyond physical health; it tries to get older people motivated, to be satisfied with their life, to carry out physical activity and to have a relationship with their family and the environment [10].

Despite this, multiple health problems and diseases that affect older people are linked to a sedentary lifestyle, which is a worrying factor since a large proportion of older people are inactive. Inactivity is the fourth highest risk factor for mortality [13,14]. A sedentary lifestyle in old age increases the deterioration of muscular function [15] and the risk of suffering cardiovascular, metabolic, respiratory and degenerative diseases [7]. All this substantiates the great importance of reducing the sedentary nature of the lifestyle of older people, with the intention of reducing health problems, diseases, functional deterioration and dependency [7,16].

The intervention in ageing should be aimed at promoting personal growth and development by facilitating environments that prevent physical, psychological and social deterioration [17]. Therefore, it is essential to create a new mentality about ageing and to involve older people in society. The promotion of active ageing is necessary to produce health benefits through physical activity for this community [1].

Regarding physical activity, it is a very useful tool for achieving successful ageing, as well as for preventing adverse effects of ageing, such as the risk of mortality, many diseases, and functional and cognitive impairment. This is due to the fact that it intervenes in the bio-psycho-social factors of older people, with the purpose of ageing with greater functional autonomy and better integration into society [7,18,19].

In short, older people guided through active ageing through physical activity not only improve their physical condition, but also improve their quality of life as they get older, reinforcing their physical, psychological and social well-being [7,19].

1.1. Autonomy and Functional Capacity in Older People

The demographic aging of the Spanish population, according to WHO data and coinciding with global and European data, is the main cause of the increase in older people with functional dependency. Therefore, the government and public institutions have developed social, health and economic policies with the intention of preventing dependency and promoting the autonomy of older people. Specifically, an active ageing policy based on physical and leisure activity is being implemented, including relevant factors for achieving personal autonomy and reducing functional dependency in old age [19].

This decrease in functional independence in older people may be due to deterioration of muscle strength and mass, balance and cardiovascular endurance [15].

The assessment of functionality and degree of dependency allows older people to prepare specific plans for their self-care and to boost their motivation, with the aim of producing independence and autonomy in their daily lives [16]. For this reason, the health of older people should not be estimated based only on the presence or absence of disease, but rather according to functionality [20].

In relation to the activities of daily living, carrying them out is fundamental to the conservation of the physical, mental and social capacities of older people [21]. On the one hand, the Barthel Index (ADL) [22] focus on self-care and mobility, giving older people autonomy and independence to live without needing help from other people. On the other hand, Instrumental Activities of Daily Living

Scale (IADL) [23] requires greater personal autonomy, and the ability to make decisions and solve problems that may arise in everyday life [24].

Consequently, regular physical activity should be promoted to preserve functionality and performance in the activities of daily living of older people [7]. Many investigations have shown the benefits of strength training to the autonomy of older people. Strength training is a very important factor in avoiding sarcopenia, optimizing functional capacity, and favoring the performance of the activities of daily living [25]. In addition, the improvement of lower body strength is of great importance for older people, since it provides them with balance and security when performing the ADL [26].

As for the physical exercise programs, those of the multi-component type where strength, resistance, balance and gait training are combined, are the most effective interventions to improve functional capacity and independence in performing the ADL in older people [27]. In addition, if these exercise programs are carried out systematically, there is an increase in strength, flexibility, aerobic capacity and balance in older people, contributing to the maintenance and improvement of their functional capacity [28].

1.2. Frailty and Risk of Falls in Older People

In the ageing process, frailty develops in older people, increasing the risk of adverse events such as functional impairment, dependency and falling [6,29]. Frailty in older people is considered a biological condition in which there is a poor response by several physiological systems to maintaining homeostasis after a stressful event [30]. As for falls, these can have physical and psychological consequences in older people, such as a fear of falling again, difficulties in walking, decreased functional capacity, needing help in performing the IADL, anxiety and depression [31].

Walking speed is a valid tool for predicting frailty in older people, which can show significant differences between healthy and frail older people since it is a variable that affects both falls and functional and cognitive deterioration [32,33]. Also, the timed up and go test is an important predictor of the risk of falls in older people [34].

Numerous investigations have proven the positive effects of physical activity on reducing adverse events caused by frailty in older people [29], since physical exercise produces improvements in strength, balance, autonomy and safety, in addition to reducing functional decline, illnesses, risk of falls, sarcopenia and disability [6,15,35]. The results of the study conducted by Mañas et al. [36] revealed that performing a physical activity of moderate to vigorous intensity is related to a greater decrease in frailty in older people when compared to the performance of a physical activity of low intensity or a sedentary lifestyle.

Multicomponent physical exercise programs are effective interventions for health and physical condition improvement in frail older people, delaying adverse events such as the risk of falls and functional impairment [15,27]. Along the same line, programs focused on strength and balance work are very effective in improving functional independence and preventing falls in older people [36]. In effect, training programs can lead to functional autonomy and the maintenance of strength and flexibility, key factors that contribute to the decrease in the risk of falls [33].

Therefore, the objectives of this study have been established based on this theoretical framework: (1) determine the differences in autonomy in the ADL and the IADL, functional capacity, frailty and risk of falls among the active group and the sedentary group in the sample, and (2) analyze the individual associations of functional capacity, frailty and risk of falls with autonomy in the ADL the IADL in the active group.

2. Methods

The research carried out was transversal and a descriptive and correlational design was used. The study variables were autonomy in the ADL, autonomy in the IADL, functional capacity, frailty and the risk of falls. The analysis variables were being in the experimental group (active) or the control group (sedentary).

2.1. Sample

The sampling was non-probabilistic but used for convenience. A total of 139 older people participated in this study, aged between 65 and 87 years (M = 73.1; standard deviation (SD) = 5.86). Of these, 100 were women (71.94%) and 39 were men (28.06%). The active group consisted of 69 older people (49.6%), and the sedentary group consistect of 70 (50.4%).

The sample came from four associations of older people based in social centers located in areas with a medium to low socio-economic level in the city of Huelva. The older people in the active group participated in a physical activity program launched by the collaboration between the City Council and the University of Huelva, while the older people in the sedentary group carried out other types of activities in these social centers. They have been classified as sedentary through the questionnaires applied in the comprehensive geriatric assessment notebook that includes the (International Physical Activity Questionnaire (IPAQ,) but this was not the main objective of this study.

In this work, the following criteria were established as inclusion criteria for delimitation of the population: older people between 65 and 90 years of age who perform some type of activity in the aforementioned social centers. If they attended the physical activity program, then they belonged to the experimental group (active), and if they performed any other type of activity, they were part of the control group (sedentary).

It should be noted that throughout the process of data collection and gathering, the current ethical and legal standards for research with human beings and for data protection were followed. The study was carried out in collaboration with the city of Huelva. They were responsible for compiling the mandatory documentation to participate in physical activity programs. The documents required were: medical certificate that enables the elderly to perform physical activity and informed consent with the research data.

2.2. Instruments

The instrument used to assess the autonomy in the ADL of the older people is the Barthel Index in Spanish [37], which was adapted from the original Barthel Index [21]. This scale assesses the ability to perform 10 basic activities of daily living on a dependent or independent basis: self-feeding, moving from a chair to a bed and back, personal hygiene and grooming, toilet hygiene, bathing and showering, transferring, going up and down stairs, dressing, and maintaining bowel and urinary control. Its score ranges between 0 (completely dependent) and 100 (completely independent) and the response categories range between two and four alternatives with five-point intervals depending on the time taken to complete it and the need for help in carrying it out. The lower the score, the greater the dependency, and the higher the score, the greater the independence. The psychometric properties of this scale show reliability and validity. For internal consistency, the Cronbach's alpha coefficient was 0.965. For the interpretation of the Barthel Index, the results are grouped into the categories proposed by Shah, Vanclay and Cooper [38]: total dependency (0–20), severe dependency (21–60), moderate dependency (61–90), low dependency (91–99) and independence (100).

To assess the autonomy in the IADL of older people, the Spanish version of the Lawton IADL Scale [39] was used, which was adapted from the original Instrumental Activities of Daily Living Scale [22]. This scale consists of 8 items: the ability to use the telephone, to shop, to prepare food, to look after the home, to wash clothes, to use means of transport, to be responsible for medication, and to manage economic matters. The answers to each item can be 0 (dependent) or 1 (independent). The final score is the sum of the value of all the responses, ranging from 0 (maximum dependency) to 8 (total independence). The psychometric properties of this scale show reliability and validity. For internal consistency, the Cronbach's alpha coefficient was 0.854.

The Vivifrail instrument [15] was used to evaluate the functional capacity, frailty and risk of falls of older people. The Vivifrail consists of the Short Physical Performance Battery Test (SPPB) and the Fall Risk Test: Timed Up and Go and Walking Speed Test (6 m). The SPPB test to determine the level of frailty is a composite of the following three separate measures: balance test (one foot next to the other, semi-tandem position and tandem position); walking speed test (4 m) and getting up from a chair. The psychometric properties of this scale show reliability and validity. For internal consistency, the Cronbach's alpha coefficient was 0.767.

2.3. Process

First, the relevant permits were obtained from the City Council and the University of Huelva for the study to be carried out. Then, after being given the information sheet on the project, titled "Intergenerational programme of physical activity and improvement of health-related quality of life: university training and social transfer", the older people of the Social Centers who wanted to participate had to sign an informed consent form.

Later, a battery of instruments was submitted for evaluation, where socio-demographic, clinical and psycho-social measures were collected. After completing these questionnaires, they were checked to make sure that they were properly filled in. Finally, in the following weeks, the Vivifrail instrument was passed to the study sample to assess their functional capacity, frailty and risk of falls.

2.4. Statistical Analysis

First, a descriptive analysis was performed to compare the study variables between the active group and the sedentary group from the sample. The Chi square test (x^2) was used to analyze the homogeneity of the groups based on belonging to the active group or the sedentary group, and to confirm that the active group and the sedentary group were matched for gender, which was statistically insignificant (p = 0.006). Then, a multivariate analysis of variance (MANOVA) was performed to compare the mean scores of the active group and the sedentary group for the study variables. The MANOVA allows dependent variables to be correlated; it is better able to detect differences between groups than an ANOVA. Third, several analyses were performed to assess the association of the study variables in the active group. Pearson correlations were made from these variables, and also from gender to identify their roles as potential confounders, but since there was no correlation, it was not used. Then, to determine the relationship between the predictive factors of the Barthel Index and the Lawton and Brody Scale for the active group, linear regressions were performed. The level of significance was set at $p < 0.05$. The statistical package SPSS Statistics 21.0 (IBM, University of Chicago, USA) for Windows was used to build the database and perform the subsequent statistical analysis.

3. Results

Table 1 shows the descriptive results for the qualitative variables of the study according to whether they belong to the active group or the sedentary group. In all of them, statistically significant differences were found.

A MANOVA was applied to determine if there were differences in the study variables between the active group and the sedentary group. A significant effect was found after multivariate contrast was performed: $V = 0.24$, F (5, 137) = 8.58, $p < 0.001$. Table 2 shows that gender did not have a statistically significant effect: $x^2 = 7.72$, $p = 0.006$. In addition, older people belonging to the active group had better values for all the variables than those in the sedentary group, producing statistically significant differences for each of them, of practically zero size ($d < 0.3$). Specifically, in the Barthel Index: F (1, 137) = 12.96, $p < 0.001$; in the Lawton and Brody Scale: F (1, 137) = 14.94, $p < 0.001$; in the SPPB: F (1, 137) = 30.19, $p < 0.001$; in the 6-m Timed Walk: F (1, 137) = 24.15, $p < 0.001$; and in the Timed Up and Go Test: F (1, 137) = 25.54, $p < 0.001$.

Table 1. Qualitative descriptive variable results of the study.

Instruments	Dimensions	Active, n (%)	Sedentary, n (%)
Barthel Index	Independence	65 (56.5%)	50 (43.5%)
	Low Dependence	1 (33.3%)	2 (66.7%)
	Moderate Dependence	3 (20%)	12 (80%)
	Severe Dependence	0	2 (100%)
	Total Dependence	0	4 (100%)
SPPB	Minimun Limitation	52 (65%)	28 (35%)
	Slight Limitation	15 (35.7%)	27 (64.3%)
	Moderate Limitation	2 (18.2%)	9 (81.8%)
	Severe Limitation	0	6 (100%)
6-m Timed Walk Test	Normal	47 (67.1%)	23 (32.9%)
	Fragility	15 (34.1%)	29 (65.9%)
	Mobility Problems and Falls	5 (29.4%)	12 (70.6%)
	Adverse Events and Falls	2 (25%)	6 (75%)
Timed Up and Go Test	Normal	58 (62.4%)	35 (37.6%)
	Fragility	11 (26.2%)	31 (73.8%)
	High Risk of Falls	0	4 (100%)

Barthel Index: $x^2(4) = 13.683$; $p = 0.008$. SPPB: $x^2(3) = 21.077$; $p < 0.001$. 6-m Timed Walk Test: $x^2(3) = 17.559$; $p = 0.001$. Timed Up and Go Test: $x^2(2) = 19.206$; $p < 0.001$. Risk of falls: $x^2(1) = 15.196$; $p < 0.001$. SPPB: Short Physical Performance Battery Test.

Table 2. Multivariate analysis of the variance of the study variables based on belonging to the active or sedentary group.

Variable	Active	Sedentary	*p*	Size of the Effect
Sex, n (%)				
Women	57 (82.6)	43 (61.4)	0.006	
Men	12 (17.4)	27 (38.6)		
Barthel Index	104.06 (3.67)	93.07 (25.08)	<0.001	0.098
Lawton and Brody Scale	7.77 (0.52)	6.87 (1.86)	<0.001	0.086
Vivifrail				
SPPB	10.41 (1.61)	8.26 (2.83)	<0.001	0.181
6-m Timed Walk Test	1.15 (0.26)	0.93 (0.26)	<0.001	0.15
Timed Up and Go Test	8.5 (1.96)	11.32 (4.2)	<0.001	0.157

Mean (standard deviation) of quantitative variables are presented as shown. *p*-values are based on MANOVA (quantitative variables) or x^2 (categorical variable). The effect size is based on Cohen's *d*. SPPB: Short Physical Performance Battery Test.

Table 3 shows the correlations between gender values, the Barthel Index, the Lawton and Brody Scale, the SPPB, the 6-m Timed Walk and the Timed Up and Go Test for the active group. Gender is not correlated with the other variables. The Barthel Index correlates significantly with the Lawton and Brody Scale ($p < 0.01$), the SPPB ($p < 0.01$) and the Timed Up and Go Test ($p < 0.01$). While the Lawton and Brody Scale has a significant correlation with the SPPB ($p < 0.01$), the 6-m Timed Walk ($p < 0.01$) and the Timed Up and Go Test ($p < 0.01$). For its part, the SPPB correlates significantly with the 6-m Timed Walk ($p < 0.01$) and the Timed Up and Go Test ($p < 0.01$). Finally, the 6-m Timed Walk has a significant correlation with the Timed Up and Go Test ($p < 0.01$).

Table 3. Pearson's correlations between sex, Barthel Index, Lawton and Brody Scale, SPPB, 6-m Timed Walk Test and Timed Up and Go test in the active group.

	A	B	C	D	E	F
Sex (A)	1	−0.119	−0.058	−0.017	−0.11	0.09
Barthel Index (B)		1	0.309 **	0.339 **	0.212	−0.378 **
Lawton and Brody Scale (C)			1	0.466 **	0.390 **	−0.414 **
SPPB (D)				1	0.678 **	−0.539 **
6-m Timed Walk Test (E)					1	−0.637 **
Timed Up and Go Test (F)						1

** The correlation is significant at the 0.01 level (bilateral).

Table 4 shows the linear regressions between the Vivifrail, the Barthel Index and the Lawton and Brody Scale in the active group. This analysis allows the frailty and risk of falls variables measured in the Timed Up and Go Test to be identified as significant predictors of autonomy in the ADL, measured by the Barthel Index as 15% (Δ Adj. $R^2 = 0.15$). It was also found that the functional capacity variable measured in the SPPB is a significant predictor of autonomy in the IADL, measured by the Lawton and Brody Scale as 22% (Δ Adj. $R^2 = 0.22$).

Table 4. Linear regression between the predictive factors of the Barthel Index and Lawton and Brody Scale in the active group.

	b	*DT*	*β*	*p*
Barthel Index				
SPPB	0.66	0.35	0.29	0.06
6-m Timed Walk Test	−3.02	2.39	−0.21	0.21
Timed Up and Go Test	−0.67	0.28	−0.36	0.02
Lawton and Brody Scale				
SPPB	0.11	0.05	0.33	0.03
6-m Timed Walk Test	0.05	0.33	0.03	0.87
Timed Up and Go Test	−0.06	0.04	−0.22	0.13

F (3) = 5.04; $p = 0.003$. F (3) = 7.41; $p < 0.001$. SPPB: Short Physical Performance Battery Test.

4. Discussion

In this study, the influence of physical activity on improving functional capacity and autonomy in the ADL and the IADL has been shown, as well as its influence on reducing the frailty and risk of falls for the older people in the sample. When comparing the two intervention groups, statistically significant differences were found: older people in the active group have better values for all the variables evaluated compared to those in the sedentary group. This may be because physical activity produces an improvement in physical condition and functional capacity, as well as a lower risk of suffering from health problems and multiple diseases due to a sedentary lifestyle [7].

Another relevant finding is that, in the active group, it was found that functional capacity is a significant predictive variable of autonomy in the IADL by 22%, while frailty and the risk of falls are significant predictors of autonomy in the ADL by 15%. In addition, all variables have significant correlations with each other, except for the Barthel Index values and the values for the 6-m Timed Walk.

First, considering the functional capacity of this study's sample, older people in the active group have a higher value than those in the sedentary group since regular physical activity is an effective tool for preserving the functional motor capacity of older people, thanks to having a healthy lifestyle [7].

Along the same lines, we find other studies, such as that carried out in [40], which show that the experimental group (who carried out a physical exercise program for 20 weeks) had an improvement in functional autonomy in the post-test compared to the pre-test values for the same group, and compared to the values for the control group, highlighting that strength training improves the functional autonomy of older people by encouraging the performance of everyday life activities. Similarly, in the study by Rodríguez-Berzal and Aguado [41], older people carried out a training program for eight weeks, with a frequency of two 25 min sessions per week, using exercises similar to the basic activities of daily living with one's own body weight, resulting in an increase in functional capacity due to a significant improvement in lower body strength and balance. In contrast, in the study by Feijó et al. [42], no statistically significant differences were found between the active and sedentary groups of older people for the functional and walking tests, although this could be due to not having controlled for the intensity of the physical activity performed by the active group.

To recap the functional capacity, on the one hand, for this study's sample's active group, 75.4% had a minimal functional limitation, 21.7% had a low limitation, 2.9% had a moderate limitation and none had a serious limitation. On the other hand, for the sedentary group, 40% had a minimal functional limitation, 38.6% had a low limitation, 12.9% had a moderate limitation and 8.6% had a serious limitation. These data show that older people who do physical activity are less likely to have functional limitations, while those who are sedentary or inactive are more likely to suffer from this type of limitation. Similarly, in the study by Velasco et al. [8] (2015), more than 50% of older people in the sample had sufficient functional capacity (that is, total independence or low dependency). In contrast, 35% of older people had a significant functional deficit.

Secondly, with respect to carrying out activities of daily living, older people belonging to the active group showed greater autonomy than older people in the sedentary group. These data agree with those of the study carried out by De Dios and Martínez [43], where, after an intervention program based on walking, statistically significant differences were found in the performance of the ADL ($p = 0.007$) and by the improvement of the functional independence of the sample's older people. Therefore, it can be assumed that carrying out physical activity promotes autonomy when performing these types of everyday activities [7,25], which are essential to maintaining the physical, mental and social capacities of older people [23]. Following the idea of Cerri [19], one should start working with older people with the assumption that the older person considered dependent has not lost their autonomy and that they need help to obtain it, since autonomy changes over time and with context through interactions with others.

In this study, a statistically significant correlation has been established between the Barthel Index and the Lawton and Brody Scale, as in the study carried out by Franco [10], since both instruments assess autonomy in the performance of the activities of daily living. Likewise, in the study by Marinês et al. [44], when linking both variables, it was found that among older people who performed the ADL independently, there was a significant percentage that required assistance to perform the IADL.

When analyzing the autonomy in the ADL for this study's sample, on the one hand, in the active group, 94.2% were independent, 1.4% had a low dependency, 4.3% had a moderate dependency and nobody had a severe or total dependency. On the other hand, in the sedentary group, 71.4% were independent, 2.9% had a low dependency, 17.1% had a moderate dependency, 2.9% had a severe dependency and 5.7% were totally dependent. This greater proportion of autonomy in the ADL of the active group may be due to participation in the physical activity program, given that they are the most effective interventions to promote the performance of the ADL in older people [27].

Recent research has also analyzed the sample based on its autonomy in performing the ADL. In the study by Córdoba et al. [11], the results reveal that 40.9% of the older people in the sample were independent in all the ADL, 19.7% were independent in all but one or two, and that there was no older person with dependency in all. In the study by Franco [10], after the analysis of the Barthel Index, it was found that 30% of the sample had severe dependency, 40% had moderate dependency and the rest had low dependency in the performance of the ADL. However in the study by Quintero and

Cerquera [20], high levels of independence were found in the performance of the ADL (specifically 62% of the sample of older people).

As for gender, it was not shown to be an influential variable for the functional capacity of the sample of this study, as there was a greater proportion of women than men. However, in many studies, gender has had an influence on the functional capacity of older people. In the study by Leirós-Rodríguez et al. [45], gender was a predictor of the functional limitations of the study sample, since men had a lower functional limitation than women for walking, climbing stairs, stooping and carrying a weight. On the other hand, in the study by Lozano et al. [46], for the most severe state of functional dependency, men had more limitations than women. Despite this, the women in the sample were more likely to go from a low to a moderate or severe functional dependency, while men were more likely to go from a low or severe functional dependency to no dependency. The results of the study conducted by Laguado et al. [16] show that, for the older people in the sample, low dependency predominates in males and independence predominates in females.

As for age, it also did not show a significant correlation with functional capacity, since it was not possible to establish age groups due to the differences in subjects that would have existed in each of these groups. However, the relationship between functional dependency increasing with age has been shown in a large fraction of research. In that by Leirós-Rodríguez et al. [45], it was shown that women had greater functional limitations from 75 years of age and men from 85 years of age. In Franco's study [10], it was shown that the increase in functional dependency occurred after 80 years of age. This relationship was also significant in the study by Silva et al. [31], showing that functional independence is lost as age goes up.

Third, the results for frailty show that older people in the active group had lower frailty than those in the sedentary group. This implies that low physical activity is a factor related to frailty in older people [47], and that carrying out moderate to vigorous physical activity is a very effective resource for reducing the adverse effects that frailty causes [36] by producing an improvement in strength, balance, autonomy, and a reduction in sarcopenia and the risk of falls in older people [6]. Similar results were obtained in the study by De Dios and Martínez [43], where older people who performed the intervention focused on walking reduced their frailty, obtaining a significant improvement in balance, coordination, stability, agility and walking speed.

For falls, older people in the active group of this study have a lower risk than older people in the sedentary group. Therefore, it has been verified that interventions focused on performing physical exercise are linked to a lower risk of falls in older people [48,49]. Similarly, in the study by Vidarte et al. [28], older people who performed an exercise program based on strength work, flexibility and walking activities (experimental group) obtained statistically significant improvements in balance ($p < 0.001$) compared to the control group, which resulted in a reduction in the risk of falls.

In this study's sample, older people in the active group had a 10.1% risk of falling; this rose to 38.6% in the sedentary group. In another study, the frequency of falls in the total sample was 35.6%, a significantly high value [34]. In the study by Silva et al. [31], the fraction of falls was 33.3%, and the majority of these were among women between 60 and 79 years old.

In this study, in the active group, a significant correlation was found between having a lower risk of falls and autonomy in the performance of both the IADL and the ADL. These data are consistent with the study by Kulzer-Homann et al. [34], in which older people who had difficulty performing at least one IADL were 78% more likely to fall than those who had no difficulty, while those who had difficulty in at least one ADL are 36% more likely to fall; that is, it was noted that not performing an ADL did not present a significant increase in the risk of falling, while not performing an IADL did significantly increase this risk.

In this case, age and gender were also not shown to be predictors of falls in this study, as in the study by Silva et al. [31], where no significant relationships were found between older people who had a fall and both analysis variables. In contrast, in the study by Kulzer-Homann et al. [34], it was shown that people 80 years old and older were 46% more likely to fall than those who were between 60 and 79 years old. In addition, women were 55% more likely to fall than men, although this could be because women have a longer life expectancy than men, although greater disability.

In short, it is absolutely necessary to achieve a culture which integrates active ageing, which must come with a change of mentality and attitude of the entire population to involve older people in all areas of society and to avoid their social exclusion [1]. It is also very important to end the sedentary lifestyle and promote the practice of systematic physical activity and healthy lifestyles in older people in order to improve their health and quality of life, as well as to prevent all kinds of adverse events and diseases that are produced [11,43,50,51].

In future studies, it would be advisable to use a quasi-experimental design in which measurements are made before (pre-test) and after (post-test) the intervention, in order to determine if the physical activity program is really the cause of the statistically significant differences found in the variables assessed in the experimental group (active) and the control group (sedentary). In addition, since an intentional non-probabilistic sampling was used, it was not possible to take into account either age or gender when analyzing the various variables, as there was a greater fraction of women than men, and different age groups could not be used. Therefore, in future research, the sample should be composed while taking into account both variables so that there is uniformity among them, and they could thus be used as analysis variables in the study. Also, a probabilistic sampling technique should be used and the sample size increased so that the results obtained could be extrapolated to the general population.

5. Conclusions

In this study, older people in the active group have better values for all the variables assessed compared to the sedentary group, showing statistically significant differences. Consequently, it has been possible to verify the influence of physical activity on improving functional capacity, increasing autonomy in performing the ADL and the IADL, and reducing frailty and risk of a fall in the older people in the sample. Further, in the active group, it was found that functional capacity is a significant predictive variable of autonomy in the IADL by 22%, while frailty and the risk of falls are significant predictors of autonomy in the ADL by 15%.

Author Contributions: Conceptualization, I.T.-Q., J.S.-P. and A.E.D.; Methodology, I.T.-Q., J.S.-P. and M.T.A.R.; Formal Analysis, I.T.-Q., J.S.-P. and A.E.D.; Resources, I.T.-Q., J.S.-P., and Á.S.R.; Writing—Review and Editing, I.T.-Q., J.S.-P., M.T.A.R. and Á.S.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Experience as a Determinant of Declarative and Procedural Knowledge in School Football

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Received: 14 January 2020; Accepted: 6 February 2020; Published: 7 February 2020

Abstract: The study of declarative and procedural knowledge makes it possible to ascertain what cognitive processes are like during motor learning. This study aimed to compare, according to the methodology, gender and experience (football practise), and the levels of declarative and procedural knowledge after the implementation of two intervention programmes on school football including one based on the tactics learning and the other on the technique learning. A total of 41 students in the 5th year of primary education from a state school from Spain, distributed in two class groups, participated in the study. Each class group participated in a different intervention programme. The sample of subjects was equal (tactical programme (n = 20) and technical programme (n = 21)). A panel of 13 experts validated both programmes. Levels of knowledge were measured using the Tactical Knowledge Assessment test in football. A descriptive analysis was performed to characterise the sample. Moreover, a t-test for independent samples, a t-test for related samples, and a 2×2 *ANOVA* (analysis of variance) were performed to compare the levels of knowledge between the pre-test and the post-test, according to the methodology, gender, and experience of the students. Results indicate that both intervention programmes induced higher levels of declarative and procedural knowledge in the post-test. Similarly, there were no significant differences with regard to the applied methodology. This fact is due to the heterogeneous character of the class groups with gender and experience showing effects on the levels of knowledge. The boys possessed greater experience and a higher level of knowledge compared to the girls.

Keywords: tactical games approach; direct instruction; gender; experience; physical education

1. Introduction

The teaching of invasion sports in primary education should be oriented toward educational objectives. Within this wide group of sports, football is the collaboration-opposition sport, which is most commonly taught in the school context in Spain [1]. Thus, the importance that football demands socially and at school leads to analysing the teaching-learning processes involved [2].

The physical education teaching approach must be in learning and, therefore, how sports are taught in physical education is as important as its content [3]. The teaching of invasion sports has traditionally focused on the technical element, leaving the tactical element to one side [4]. This implies the existence of deficits in the teaching-learning process regarding cognitive structures [5]. Following this line of thought, several studies have analysed the Student-Centered Approaches (SCAs) or tactics and the Teacher-Centered Approaches (TCAs) or technique, with the idea of contrasting which teaching methodologies induce higher levels of technical-tactical knowledge with significant differences being observed in the variables related to understanding the game like declarative knowledge or decision-making in favour of the SCAs [6,7]. Within the SCAs, the Tactical Games Approach (TGA) method stands out, and, within the TCAs, the Direct Instruction (DI) method is the most common [8].

The TGA method gives students the opportunity to learn through the real game. The teacher generates the learning through questions and interrogative feedback while encouraging decision-making. On the other hand, in the DI method, the students participate in technical components or drills. The teacher gives direct information to the students including prescriptive feedback, and they execute according to the guidelines given [9,10]. The TGA method is more successful than the DI method because it bases its learning on small-sided games. The students play with modified rules, fewer students, in tight spaces, etc., which improves tactical understanding when making decisions [11]. The DI method causes little learning progression because the students participate in isolated and descontextualized tasks of the real game [12]. For all these reasons, the TGA method is more appropriate for teaching invasion sports in physical education classes.

In the school context, several studies compare methodologies in different aspects like learning [7,13], and external and internal load [14], after the implementation of two different intervention programmes for basketball, with one based on a traditional methodology (Direct Instruction in Basketball) and another on an alternative methodology (Tactical Game in Basketball). There is also another study on teaching methodologies after the implementation of intervention programmes for football [15].

MacPhail et al. [11] highlight the importance of teaching technical-tactical aspects in invasion sports from the SCAs, based on integrating and total teaching, rather than TCAs, centered on teaching technical skills. Perceptive and cognitive factors take on greater importance in SCAs given their influence on decision-making and the transfer of learning [16]. Light et al. [17] point out that SCAs improve the ability to game, increase students' motivation, and provide positive affective learning experiences. Similarly, the teachers are the ones in charge of designing play tasks, which help the learners to develop knowledge and give them the opportunity to acquire interrelated technical-tactical aspects [18].

The students make decisions during sports practice thanks to the structures of prior knowledge that they possess and their ability to process new information [19,20]. In the same way, the students possess a great capacity to acquire knowledge at an early age [18]. Moreno et al. [21] indicate two types of knowledge: declarative and procedural. On the one hand, declarative knowledge refers to theoretical information that includes both technical-tactical aspects and rules. On the other hand, procedural knowledge refers to (tactical) decisions made in concrete game situations. Chatzipanteli et al. [9] indicate that students must have adequate declarative knowledge to improve procedural knowledge. Declarative knowledge must be conducted prior to problem solving and decision-making.

The level of the students' knowledge and their ability to make decisions are fundamental factors for effective sports practice [22]. Tactical knowledge will favour the development of decision-making skills during sports practice [23]. Similarly, an adequate base of prior knowledge together with different factors such as experience or formal instruction will help the students make game decisions in a more efficient manner [24]. Williams et al. [25] and García et al. [26] indicate that declarative and procedural knowledge are acquired through sports practice, differentiating the expert students from the novices in the structured memory, which they acquire with the practice of sport and the specific knowledge that they possess. For this reason, different studies conclude that the levels of knowledge and the experience of the students are intimately linked with students with more experience presenting higher levels of knowledge [27–29].

Regarding gender, both in the context of sports training and of the school, boys are associated with sports that involve physical contact, strength, and aggressiveness: football, basketball, handball, etc. On the other hand, girls are associated with sports related to rhythm and beauty such as gymnastics, figure skating, dance, etc. [30,31]. In spite of studying gender with respect to different variables, especially psychological ones [32,33], the research on differences in sports learning according to gender are scarce [34].

In general terms, experience (sport practice) and gender are two mediating variables that can explain the differences in the levels of declarative and procedural knowledge recorded in physical education classes regardless of the teaching method applied by the teacher. In the Serra-Olivares [34] study, boys recorded higher levels of declarative and procedural knowledge than girls. In addition, the students with the most experience also recorded better results. This same author indicates that more studies are needed to analyze the relationships between experience, knowledge, skill, and gender in school sports.

The scientific literature includes research on the declarative and procedural knowledge of young students, after being taught football, in the school context [34–36] and in the context of sports training [18,25,37]. Research on football tends to study elite players [38]. In addition, many interviews, videos, questionnaires, and written tests are used as tools to evaluate the knowledge of learners in football [39].

Studying declarative and procedural knowledge makes it possible to ascertain students' cognitive processes [2]. This knowledge is of great importance in the teaching-learning process of an invasion sport such as football [39]. The literature does not include studies, which, as well as analysing declarative and procedural knowledge, take into account the gender and level of experience of the students. The teaching of football in the Spanish educational system is common since it is necessary to study the influence exerted by the experience of the out-of-school activity in the school context. Thus, the purpose of this study was to compare, according to the teaching method, gender and experience (football practise), the declarative and procedural knowledge acquired by two groups of students from the 5th year of a state school in Spain after the implementation of two intervention programmes on school football. Each intervention programme was based on a different method, TGA and DI, and each programme was applied in a different class group.

2. Materials and Methods

2.1. Design

A quasi-experimental longitudinal design was used with a pre-test and a post-test [40] to determine if there were differences in the level of declarative and procedural knowledge after the implementation of two intervention programmes on school football.

2.2. Sample

A total of 41 students, aged 10 or 11 years (Age: 10.63 ± 0.488 years), from the 5th year of primary education from a state school in the west-central region of Spain, participated in the study. They were divided into two class groups depending on the intervention programme applied. The distribution by gender in each class in the Spanish state system is mixed and heterogeneous, and it is organized by the school's academic authorities. The implementation of the programmes to the groups was random. The students from the 5th year group A participated in the Tactical Games Approach Soccer (TGAS), and the students from the 5th year group B in the Direct Instruction Soccer (DIS) intervention programme. To be able to take part in the study, it was necessary for the parents or legal guardians to sign their informed consent. Moreover, this study was included in the school's curricular project.

The students had no previous contact with the invasion sport of football in their physical education classes, although 15% of the students who participated in the TGAS intervention programme and 42.9% of those who participated in the DIS intervention programme practised football as an out-of-school activity (or as sports training) 4 hours per week, which was divided into 3 hours training and a one-hour official match. All these students were boys. None of the girls from either group practised football as an out-of-school activity. Moreover, 40% of the students who participated in the TGAS programme and 71.43% of the students who participated in the DIS programme were boys.

This heterogeneous character of the class groups regarding level of practise and gender was conditioned by the random distribution of the students, according to the Spanish educational system, which does not segregate students according to gender. The groups were not modified to maintain the ecological validity of the study.

The characteristics of the students participating in the study are shown in Table 1.

Table 1. Characteristics of the students participating in the study.

Methodology and Class Group	Gender				Experience (Football Practice)			
	Boy		Girl		Yes		No	
	n	%	*n*	%	*n*	%	*n*	%
TGAS (5 A)	8	40.00	12	60.00	3	15.00	17	85.00
DIS (5 B)	15	71.43	6	28.57	9	42.90	12	57.10

Note: TGAS: Tactical Games Approach Soccer. DIS: Direct Instruction Soccer.

2.3. Variables

Three independent variables were determined: i) the TGAS (based on the TGA method) and the DIS (based on the DI method) intervention programmes were designed in a similar manner, but were based on different methodologies. Both intervention programmes were similar ($p > 0.05$) with a high degree of association in different variables, in terms of: the number of tasks, the number of sessions, the phases of play, the specific contents, and the didactic objectives. Differences were identified in the rest of the studied variables due to the particularities of each teaching methodology, i.e., game situation, teaching means, level of opposition, degree of opposition, density of the task, competitive load, and cognitive implication ($p < 0.05$) [41]. The TGAS and DIS programmes were validated by a panel of 13 judicial experts (Aiken's V ≥ 0.69, $\alpha = 0.97$). To be considered as an expert judge, they had to meet a series of criteria: having a Doctoral degree, being a Higher Education faculty member in the area of sport pedagogy and/or invasion sports, possessing the highest federative certification level (level III) in invasion sports, having 10 years of experience or more as an invasion sports coach, or having authored publications on sport pedagogy and/or teaching methods [42], ii) the gender of the students, and iii) the practice of football as an out-of-school activity, that is the experience of the students in football.

The TGAS and DIS programmes present optimal levels of validity and reliability. Thus, both are considered valid and reliable for the teaching of football in the school context as well as for analysing the level of learning attained by the students after their implementation [42].

The dependent variable for the study was the levels of declarative and procedural knowledge [21] acquired by the students after the implementation of the intervention programmes. Both types of knowledge are related to the attack phase in football.

2.4. Instruments

The declarative and procedural knowledge of the studied students was analysed using the Tactical Knowledge Assessment test in Football (TCTOF by its Spanish acronym). This instrument is a written multiple-choice test divided into two parts. The first part is in written form and evaluates declarative knowledge ("to know what, and why to do it") and the second part written with representative figures of a game situation to evaluate procedural knowledge ("to know how and when to do it") [39]. The TCTOF is linked to the action principles of invasion sports [43].

Table 2 shows the indicators evaluated by the TCTOF for declarative and procedural knowledge [39].

Using consensual agreement [44], it was decided to eliminate nine of the 36 items aimed at evaluating declarative knowledge and one of the 16 items aimed at evaluating procedural knowledge since they presented greater complexity with regard to the educational stage of the participating students.

Lastly, the data collected using the TCTOF were exported to the SPSS 21.0 statistical program (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21., IBM Corp, Armonk, NY, USA) for their later descriptive and inferential analysis.

Table 2. Indicators evaluated by the TCTOF.

Declarative Knowledge
• Individual technical-tactical elements in football, related to action principles for attack. • Individual technical-tactical elements in football, not related to action principles for attack. • Group technical-tactical elements in football. • Action principles for attack in invasion games and sports.
Procedural Knowledge
• Individual technical-tactical elements in situations of maintaining possession of the ball in football. • Individual technical-tactical elements in situations of advancing towards the opponent's goal in football. • Individual technical-tactical elements in situations of scoring a goal in football.

Note: TCTOF: Tactical Knowledge Assessment test in football.

2.5. Procedure

First, despite the fact that the study did not require invasive measures to obtain the data, the University Bioethics Committee was asked for its approval (Ref. 09/2018). Then authorisation was requested from the school and the physical education teachers. Once authorisation was obtained, the parents or legal guardians of the students were asked for their informed consent by signing a document that was in accordance with the ethical guidelines of the Declaration of Helsinki and Organic Law 15/1999 of 13th December on the Protection of Personal Information (LOPD) (BOE 14 December 1999). Similarly, the study was approved by the school council within the school curriculum.

After obtaining the necessary authorisations, an initial evaluation was conducted, including the pre-test, in which the students completed the TCTOF. This evaluation also included for the study purposes the following information: i) the school year (5A or 5B), ii) age in years, iii) years of football practice (1, 2, 3, 4, or more than 5), and iv) football practice in the out-of-school context (Yes or No).

After that, the TGAS and DIS programmes were implemented, with one to each class group for 11 sessions, including sessions of the 3×3 games of the pre-test and post-test. The teaching progressed based on the difficulty of the tasks. The teacher's communications were also adapted to the type of feedback characteristic for each methodology [41].

Lastly, after the application of the intervention programmes, there was a final evaluation, which is the post-test, when the students again completed the TCTOF.

The pre-test and post-test assessments lasted 55 minutes each, and each time, the principal investigator explained the TCTOF, so that it was completely clear how it had to be filled out.

Figure 1, which was designed by García-Ceberino et al. [15], summarizes the structure of the TGAS and DIS intervention programmes.

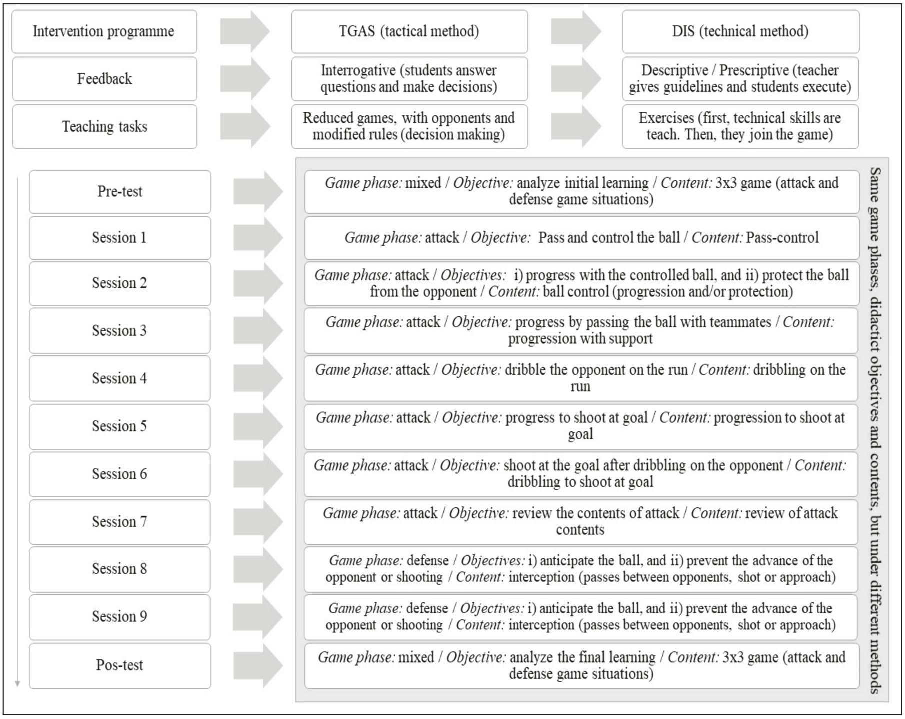

Figure 1. Structure of the TGAS and DIS intervention programmes. Note: TGAS: Tactical Games Approach Soccer. DIS: Direct Instruction Soccer.

2.6. Statistical Analyses

Firstly, the tests of assumption of criteria were conducted to identify the characteristics of the study data [45]. The Shapiro-Wilks and Levene tests showed that the study variables fulfilled the assumption of normality, so that mathematical parametric models could be used to test the hypothesis.

A descriptive analysis was then performed to ascertain the participants' characteristics according to gender and experience in football. Then, a t-test for independent samples was performed to compare the level of declarative and procedural knowledge between both class groups (pre-test). Similarly, a t-test for independent samples was conducted to contrast the level of declarative and procedural knowledge resulting from the implementation of both intervention programmes (post-test) [45].

A t-test for related samples was also performed to contrast the level of declarative and procedural knowledge acquired by the students in each class group after the implementation of the intervention programmes (post-test) with respect to their initial level (pre-test) [45].

Lastly, to determine the effect that gender and experience in football had in the study in both methodologies on the level of declarative and procedural knowledge acquired by the students after the implementation of the intervention programmes (post-test), a 2×2 *ANOVA* for repeated measures was performed [45], using gender and experience as co-variables.

Figure 2 presents the statistical tests used to compare the declarative and procedural knowledge in the pre-test and post-test, according to the methodology, gender, and football experience.

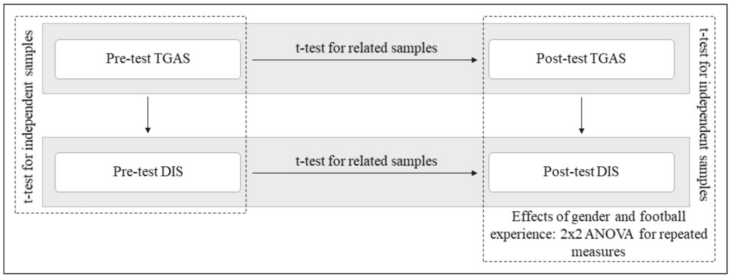

Figure 2. Statistical tests used to compare the declarative and procedural knowledge in the pre-test and post-test. Note: TGAS: Tactical Games Approach Soccer. DIS: Direct Instruction Soccer.

The effect size of the statistical analyses was determined using Cohen's d (d_{cohen}) and partial eta squared (η2) [46,47].

3. Results

The descriptive results for each intervention programme according to gender and experience in football are presented in Table 3. The boys who participated in each programme presented higher levels of declarative and procedural knowledge in the pre-test and post-test compared to the girls. Similarly, the students from both groups who practised football as an out-of-school activity presented higher levels of declarative and procedural knowledge in the pre-test and post-test.

Table 3. Descriptive results of the pre-test and post-test according to gender and football experience.

Programme	Knowledge	Gender	Pre-test M ± SD	Post-test M ± SD	Pre-Post
TGAS (5 A)	Declarative	Boy	45.83 ± 9.69	52.31 ± 16.01	−6.48
		Girl	36.11 ± 9.75	41.05 ± 14.08	−4.94
	Procedural	Boy	34.17 ± 16.11	44.17±15.91	−10.00
		Girl	30.00 ± 14.35	28.33 ± 8.59	1.67
	Knowledge	**Experience**	**Pre-test M ± SD**	**Post-test M ± SD**	**Pre-Post**
	Declarative	Yes	49.38 ± 2.14	65.43 ± 5.66	−16.05
		No	38.34 ± 10.71	42.05 ± 13.98	−3.71
	Procedural	Yes	48.89 ± 16.78	60.00 ± 6.67	−11.11
		No	28.63 ± 12.64	30.20 ± 9.46	−1.57
Programme	**Knowledge**	**Gender**	**Pre-test M ± SD**	**Post-test M ± SD**	**Pre-Post**
DIS (5 B)	Declarative	Boy	51.11 ± 9.10	57.04 ± 14.47	−5.93
		Girl	37.04 ± 17.37	43.21 ± 14.57	−6.17
	Procedural	Boy	39.55 ± 10.83	48.89 ± 21.48	−9.34
		Girl	22.22 ± 8.07	24.44 ± 9.11	−2.22
	Knowledge	**Experience**	**Pre-test M ± SD**	**Post-test M ± SD**	**Pre-Post**
	Declarative	Yes	50.62 ± 8.69	57.20 ± 16.57	−6.58
		No	44.44 ± 15.71	50.00 ± 14.60	−5.56
	Procedural	Yes	42.96 ± 11.60	56.30 ± 23.12	−13.34
		No	28.33 ± 9.90	31.11 ± 13.13	−2.78

Note: M: Mean. SD: Standard Deviation. TGAS: Tactical Games Approach Soccer. DIS: Direct Instruction Soccer.

Table 4 compares the level of declarative and procedural knowledge between both class groups in the pre-test and post-test. It shows that the students who participated in the DIS programme presented higher levels of initial declarative and procedural knowledge (pre-test) than the students who participated in the TGAS programme. However, these differences were not statistically significant ($p > 0.05$) with an intermediate effect size (0.500–0.799) in the level of declarative knowledge and small (0.200–0.499) in the level of procedural knowledge. After the implementation of the intervention programmes (post-test), the students who participated in the DIS programme continued to show higher levels of declarative and procedural knowledge than the students who participated in the TGAS programme. However, the differences were not statistically significant ($p > 0.05$) and showed a small effect size (0.200–0.499).

Table 4. Level of declarative and procedural knowledge between both class groups in the pre-test and post-test.

Test	Knowledge	Programme	n	M ± SD	t	df	p	d_{cohen}
Pre-test	Declarative	DIS	21	47.09 ± 13.26	1.882	39	0.067	0.588
		TGAS	20	40.00 ± 10.65				
	Procedural	DIS	21	34.60 ± 12.76	0.681	39	0.500	0.213
		TGAS	20	31.67 ± 14.81				
Test	**Knowledge**	**Programme**	n	*M± SD*	t	df	p	d_{cohen}
Post-test	Declarative	DIS	21	53.09 ± 15.51	1.553	39	0.129	0.485
		TGAS	20	45.55 ± 15.53				
	Procedural	DIS	21	41.90 ± 21.72	1.258	39	0.216	0.393
		TGAS	20	34.67 ± 14.12				

Note: M: Mean. SD: Standard Deviation. df: degrees of freedom. TGAS: Tactical Games Approach Soccer. DIS: Direct Instruction Soccer. * $p < 0.05$.

The level of declarative and procedural knowledge acquired by the students in each class group, after the implementation of the two intervention programmes (post-test), is shown in Table 5. It can be seen that both class groups present higher levels of declarative and procedural knowledge with regard to their initial level (pre-test). There were significant differences ($p < 0.05$) with a small effect size (0.200–0.499) in the level of declarative and procedural knowledge between the pre-test and post-test of the class group that participated in the DIS programme. However, there were no significant differences ($p > 0.05$) and with a small effect size (0.200–0.499) in the level of declarative and procedural knowledge between the pre-test and the post-test of the class group that participated in the TGAS programme.

Table 5. Level of declarative and procedural knowledge acquired in each class group (pre-test/post-test).

Programme	Knowledge	n	M ± SD	t	df	p	d_{cohen}
DIS	Declarative pre-test Declarative post-test	21 21	47.09 ± 13.26 53.09 ± 15.51	−2.274	20	0.034 *	0.411
	Procedural pre-test Procedural post-test	21 21	34.60 ± 12.76 41.90 ± 21.72	−2.368	20	0.028 *	0.339
TGAS	Declarative pre-test Declarative post-test	20 20	40.00 ± 10.65 45.56 ± 15.53	−1.899	19	0.073	0.401
	Procedural pre-test Procedural post-test	20 20	31.67 ± 14.81 34.67 ± 14.12	−1.013	19	0.324	0.207

Note: M: Mean. SD: Standard Deviation. df: degrees of freedom. TGAS: Tactical Games Approach Soccer. DIS: Direct Instruction Soccer. * $p < 0.05$.

Table 6 presents the effect that gender and experience in football have in the two methodologies studied on the level of declarative and procedural knowledge acquired by the students. Regarding gender, it can be seen that there were no significant differences ($p > 0.05$) and, with a small effect size (0.010–0.059), in declarative knowledge and no effect (0.000–0.009) in procedural knowledge, according to the methodology used. However, there were significant differences ($p < 0.05$) with a large effect size (≥0.140) in both types of knowledge, according to the gender, so that this variable affects the levels of declarative and procedural knowledge acquired by both class groups. Similarly, with respect to the students' experience in football, we can see that there were no significant differences either ($p > 0.05$) and, with a small effect size (0.010–0.059) in declarative knowledge and no effect (0.000–0.009) in procedural knowledge, according to the methodology used. However, there were significant differences ($p < 0.05$) and, with an intermediate effect (0.060–0.139), in declarative and a large effect (≥0.140) in procedural knowledge in the experience variable, so that practising football in an out-of-school context also affects the levels of declarative and procedural knowledge acquired by both class groups.

Table 6. Effect of the methodologies on gender and experience in football.

	Knowledge	Variable	*df*	*Quadratic M*	*F*	*p*	*η2*
Gender	Declarative	Intersection	1	32236.844	131.589	0.000 *	0.776
		Gender	1	2671.214	10.904	0.002 *	0.223
		Methodology	1	225.811	0.922	0.343	0.024
	Procedural	Intersection	1	26126.118	77.448	0.000 *	0.671
		Gender	1	4163.195	12.341	0.001 *	0.245
		Methodology	1	2.010	0.006	0.939	0.006
Experience	Declarative	Intersection	1	20135.160	73.660	0.000 *	0.660
		Experience	1	1593.121	5.828	0.021 *	0.133
		Methodology	1	371.978	1.361	0.251	0.035
	Procedural	Intersection	1	26091.556	101.178	0.000 *	0.727
		Experience	1	7182.556	27.852	0.000 *	0.423
		Methodology	1	16.116	0.062	0.804	0.002

Note: *M*: Mean. *df*: degrees of freedom. * $p < 0.05$.

4. Discussion

Currently, declarative and procedural knowledge are tools used to assess cognitive aspects in the evaluation of invasion sports like football [2]. This research has contributed to the study of levels of declarative and procedural knowledge resulting from the implementation of two intervention programmes, based on two different teaching methodologies, in two groups of students in primary education of a state school in Spain. The results indicate that the TGAS and DIS programmes induced improvements in the levels of declarative and procedural knowledge in both class groups. Moreover, the students who did not have knowledge of football improved and, those who did have knowledge, improved even more. The students' gender and experience (football practice) affected the levels of declarative and procedural knowledge in the pre-test and post-test. The students from both class groups had more difficulties with regard to procedural knowledge (behaviours or strategies to be used in different play situations).

Different studies carried out on invasion sports like football [6] or basketball [7] state that the SCAs or tactics induce higher levels of knowledge. In this research, the students who participated in the DIS programme, based on technique, showed significant differences in declarative and procedural knowledge between the pre-test and the post-test, while the students who participated in the TGA programme, based on tactics, did not present significant differences in declarative and procedural knowledge between the pre-test and post-test. This may be due to the effect of the students' gender and experience in the teaching of the invasion sport of football. In this respect, 40% of the students who participated in the TGAS programme were boys and 15% practised football in an out-of-school context while 71.43% of the students who participated in the DIS programme were boys and 42.9% practised football in the out-of-school context. None of the girls had experience in football. The boys' percentage and experience in football was very low in the TGAS programme. Therefore, this programme did not present significant differences. Several studies have identified the fact that boys are more interested in practising football than girls both in the school playtime [48] and in an out-of-school context [49]. In this study, the students who had no knowledge of football improved equally independently of the method and, the students who did have knowledge, improved even more with the TGAS programme.

The characteristics of the students who participated in the study show the heterogeneity of the groups, which may have affected the results. Different studies indicate that the multiplicity of behaviours and/or solutions that invasion sports offer within a class group with very dissimilar capacities and knowledge make the teaching task very difficult [50,51]. Spatial and reglementary adaptations are needed to facilitate the teaching and evaluation of football in the school context [52].

Other similar studies that compared the effects of implementing two intervention programmes for school basketball using different methodologies based on TGA (Tactical Game is Basketball) and DI (Direct Instruction in Basketball) found improvements with both intervention programmes, but the students who participated in the TGA programme reached a higher degree of learning [7,13]. Equally, in the analysis of the physical demands involved with the implementation of these programmes and their relation with the learning acquired by the students, it was found that the TGA methodology produced better results in the variables of an external and an internal load than the DI methodology, which permits a greater development of physical fitness in the students and better performance indicators in the game [14]. García-Ceberino et al. [15] also indicated that the TGA method favors the physical fitness of students. These results led to the recommendation that physical education teachers use a TGA method for teaching invasion sports in physical education classes [53].

Students have different levels of knowledge as a function of their experience in sports practice [27, 29]. Persky et al. [54] state that the main element that differentiates novice students from the experts is decision-making. The results obtained in this study indicate that the students with more experience reached a higher level of declarative and procedural knowledge. However, the students who participated in the TGAS intervention programme learned more. According to Serra-Olivares et al. [23], the level of specific knowledge of football and the experience of the students are intimately related. The results of this investigation coincide with several studies where the structures of technical-tactical knowledge and decision-making in football were analysed in the school context including in secondary education [36] and in primary education [34] as well as in the out-of-school context [18,55]. Experience determines the learning attained by the students since knowledge is acquired by practising the sport. The boys participating in the study tend to practise out-of-school football more often than the girls, which means that the former reached higher levels of knowledge in the pre-test and post-test.

The level of declarative knowledge acquired by both groups was higher than the level of procedural knowledge. This could be due to the fact that the teaching they have received in previous years has been more focused on technical aspects, without taking into account the strategies to be implemented during the game (tactical decisions) and the difficulties for interpreting the most suitable tactical decision in each play situation [37]. This study highlights the importance of making the right decision depending on the situation that is presented and, on this basis, choosing the technical-tactical element to be implemented. Similarly, the processes of learning and decision-making are influenced by the egocentrism that characterises students of these ages, which leaves the group aspects of the game [43]. The problem of the students to interpret the most suitable tactical decisions in every game situation that is considered can be due to the tendency of teachers to use TCAs for teaching invasion sports in physical education classes [56], which suppresses creativity and decision-making.

Lastly, the gender of the students also affected the level of declarative and procedural knowledge. Boys present higher levels of knowledge than girls. Serra-Olivares [34] identified that the gender variable was determinant in the levels of declarative and procedural knowledge of students of primary education. The boys showed significantly higher levels of knowledge than the girls. This is because they tend to practise football more often. This could be because boys tend to practise sports that involve physical contact, strength, and aggressiveness such as football, basketball, handball, etc. whereas girls tend to practise sports involving rhythm and beauty such as gymnastics, figure skating, dance, etc. [30,31]. Slingerland et al. [57] indicate that playing invasion games in school (football, handball, basketball, etc.) could be a strategy for the physical education teachers to foment the perceived competence of the girls and their physical activity in this type of game.

Thus, the findings of this study could suggest that the differences in the levels of declarative and procedural knowledge of the students participating in the study are due to the effect of their gender and experience in football, which highlights the heterogeneous distribution of groups in physical education classes. The random distribution of the students, according to the Spanish educational system, conditions the heterogeneous distribution of the groups regarding the level of practice and gender. Further research is needed to delve more deeply into the study of cognitive structures of players at the sports initiation stage [27]. Following this line of thought, there are few studies that analyse declarative and procedural knowledge in the school context and, in particular, in primary education [34,58].

The students were not grouped in homogeneous groups due to the legal organization of the class groups. However, this fact allowed us to learn about the influence of gender and previous experiences in the results. Likewise, new research studies including more participants are needed to improve and provide more information.

The Spanish educational system recommends using the technical and tactical contents common to invasion sports. The transfer between invasion sports with a similar internal logic can be studied through declarative and procedural knowledge. Students can transfer knowledge between different sports by providing common solutions to the same tactical problem. In this sense, the SCAs are more favorable for the transfer of knowledge [16,59]. This research missed studying whether the students who participated in both intervention programmes were able to transfer the acquired knowledge to other invasion sports with the same internal logic. The study of knowledge transfer between common sports is recommended for future research. In addition, it is necessary to study the influence of gender and experiences in learning other sports.

5. Conclusions

The results show that the TGAS and DIS intervention programmes induced improvement in the levels of declarative and procedural knowledge. However, there were no significant differences between the groups according to the teaching method used. The heterogeneous nature of the groups regarding gender and experience affected the levels of declarative and procedural knowledge after the application of the intervention programmes. The boys had greater experience and a higher level of knowledge. The students who had no knowledge of football improved equally independently of the method and, those who did have knowledge, improved even more with the TGAS intervention programme. Similarly, the level of declarative knowledge shown by both groups was higher than that of procedural knowledge, which shows knowledge is more centred on the technical aspects than on the behaviours and/or strategies that should be used (tactical decisions). Thus, further research is needed to study the methodologies for the teaching of invasion sports such as football at the primary education stage and their relation with students' cognitive structures.

Author Contributions: Conceptualization, J.M.G.-C., S.F., and S.J.I. Methodology, J.M.G.-C., S.F., and S.J.I. Formal analysis, J.M.G.-C. Reviewers, M.G.G., S.F., and S.J.I. Writing—original draft preparation, J.M.G.-C. Writing—review and editing, M.G.G., S.F., and S.J.I. Visualization, J.M.G.C. Supervision, M.G.G., S.F., and S.J.I. All authors have read and approved the manuscript.

Funding: This study has been partially subsidized by the Aid for Research Groups (GR18170) from the Regional Government of Extremadura (Department of Employment, Companies and Innovation), with a contribution from the European Union from the European Funds for Regional Development.

Acknowledgments: The authors thank the Rodeo school, the physical education teachers, and the students for participating in the research.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Perfectionism Profiles and Anger Responses: The Relevant Role of Self-Esteem in Athletes of Professional Quarries

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Received: 3 February 2020; Accepted: 17 February 2020; Published: 22 February 2020

Abstract: Perfectionism is a multidimensional personality trait characterized by effort and rigidity in setting high personal standards, accompanied by an excessive tendency toward critical assessments, which plays an important role in cognitive, behavioral, and emotional functioning. During adolescence, personality is built on a fundamental pillar—self-esteem—which plays an important role in sports practice when it comes to achieving the best possible performance. Anger has an emotional component that, interpreted in an unadaptive way, interferes with sports performance. The aim of this study is to assess differences according to self-esteem and perfectionism indicators and anger expression and management in young athletes. The sample included 229 male athletes to the quarries of professional sports with ages between 13 and 17 years. They were administered the Multidimensional Perfectionism Scale, the State-Trait Anger Expression Inventory for Children and Adolescents, the Rosenberg Self-esteem Scale, and a socio-demographic questionnaire. Predictive analysis showed that low personal standards and high levels of organization (indicators of adaptive perfectionism) acted as predictors of state anger, while those showing high personal standards predicted high anger management in athletes with high self-esteem. High personal standards predicted lower indicators of trait anger in athletes with low self-esteem. The results revealed the influence of high self-esteem as a protective factor in the predictive relationship among anger traits and personal standards. The study describes the relationship of these variables in the belongings of young male footballers (under high sport pressure), showing the need to take care of the athletes' self-esteem in sport environments through prevention programs that include psychological and social resources training systems.

Keywords: anger expression; personality; perfectionist efforts; sports technology

1. Introduction

Over the last few decades, a series of studies carried out with athletes [1–3] and with other performance-related populations [4–7] have promoted advances in the study of perfectionism by relating it to functional and adaptive aspects. Thus, perfectionism is now defined as a multidimensional personality trait characterized by effort and rigidity in setting high personal standards, accompanied by an excessive tendency toward critical assessments [6–8], which plays an important role in cognitive, behavioral, and emotional functioning [8–10]. Being a multidimensional construct, it has been studied using different models and measures, and thus dimensions based on intrapersonal and/or interpersonal aspects have been found. According to previous research [11–13] as to how perfectionist dimensions participate in the behavioral regulation individually, perfectionism has been associated with adaptative or maladaptive aspects. Perfectionism has been associated with adaptive aspects described by factors such as achievement expectations (the tendency to set high goals and carry out excessive self-evaluation) and organization (emphasis on the importance of order and coherence in aims proposed). On the other hand, the maladaptive aspects are described by factors such as external expectations (understood as athletes' perception of their family and coaches' high expectations) and the fear of making mistakes (excessive concern in relation to mistakes and failure, which causes doubts and ruminations about the quality of their performance).

On previous dimensions, Gaudreau and Thompson (2010) have created a 2 × 2 model of perfectionism (Figure 1), where they have differentiated four categories: nonperfectionism (low personal standards, low evaluative concerns), maladaptive perfectionism (low personal standards, high evaluative concerns), adaptive perfectionism (high personal standards, low evaluative concerns) and mixed perfectionism (high personal standards, high evaluative concerns).

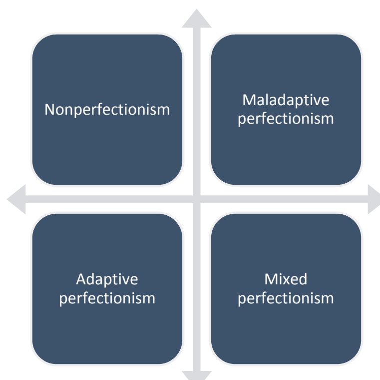

Figure 1. The 2 × 2 model of perfectionism (Gaudreau and Thompson, 2010).

In young people's sporting performance, perfectionism is seen as a predictor of adaptation and psychological well-being when figures in the sporting context (e.g., coaches or parents) and themselves focus their efforts on how to realistically achieve the proposed goals and provide appropriate support [13–16]. In contrast, perfectionism predicts psychosocial maladjustment when the environment is contradictory (e.g., different rules of behavior at home and in the sports context) or too much rumination or low emotional self-regulation are part of the beliefs of athletes [16,17]. Thus, when the approval and affection received by a competing athlete is conditioned by the attainment of unrealistic goals or performance standards, associations with emotional difficulties and self-esteem linked to dysfunctional thoughts have been found [2,17].

Personality is fundamentally built on self-esteem, its stability shares a common development and interacts with beliefs about how to achieve goals, both autonomously and guided by other significant figures (e.g., parents, coaches, teachers, etc.) [18,19]. Self-esteem is defined as the positive or negative assessment that athletes make about themselves and their identity. It also expresses the ability to feel competent, capable, and successful that derives from a persons' perception of dissonance or similarity in relation to the achievement of ideal personal values or standards. Thus, the level of self-esteem can be similar to perfectionism in the process of comparison between values and discrepancies. A minimum distance perceived between the "ideal self" and the "real self" results in healthy self-esteem. In this process of comparison, self-criticism manifests a radical importance, which, in individuals with low self-esteem, is usually excessive and leads to permanent dissatisfaction [20].

Therefore, as previous studies have shown [2,21], the sports environment is an ideal context for studying self-esteem in adolescence and its relationship with psychological processes when taking into account their enhancing or threatening status. Competition and the agents that surround sport have a high emotional impact on young people that sometimes leads to the abandonment of sport activity at an early age [22]. At the same time, the literature has shown that high levels of self-esteem are associated with health and psychological well-being [23], pressure or anxiety management [2], and sports performance [22]. Ichraf et al. [21] studied the association between high levels of self-esteem and low levels of anxiety in young athletes in individual sports and observed that self-esteem could function in terms of emotional control or as a protective mechanism against unadaptive situations.

Anger has an emotional component that, when interpreted in an unadaptive way, interferes in a negative way with the learning derived from sports practice. However, anger can make it possible to compete while following sport rules and social behavior with high intensity and activation, but without intent to harm or injure opponents [24]. Furthermore, different studies have suggested that adequate anger management could become a protective health factor [25,26], so that anger would have a variety of adaptive functions, including the regulation of internal psychological and physiological processes related to self-defense, along with the regulation of interpersonal and social behaviors. This emphasizes the importance of ascertaining the internal mechanisms that activate or regulate self-perception and the expression of unadaptive anger, since the latter acts as a mediator between frustration and aggression (behavior aimed at causing harm to people or things).

The objective of the study is to assess the differences between levels of self-esteem and indicators of perfectionism and anger expression and management in young athletes. The starting hypothesis are as follows:

Hypothesis 1. *Athletes with higher levels of self-esteem will show higher values in adaptive perfectionism indicators (organization and personal standards) and anger management.*

Hypothesis 2. *Athletes with low levels of self-esteem will show higher values in unadaptive perfectionism indicators (external expectations and fear of making mistakes) and state and trait anger.*

Hypothesis 3. *Athletes with no perfectionism and adaptive perfectionism profiles will be associated with lower anger and high self-esteem.*

Hypothesis 4. *Athletes with mixed perfectionism profiles will be associated with anger and lower self-esteem.*

2. Materials and Methods

2.1. Participants

The sample consisted of 229 male teenage athletes to the quarries of professional sports from different cities of Spain, selected according to accidental sampling. The age range of athletes was between 13 and 17 years old (M = 14.43; SD = 1.37). Their age distribution was 13 (34.5%), 14 (23.6%), 15 (17.5%), 16 (13.5%), and 17 (10.9%).

This study was carried out in accordance with the ethical guidelines of the American Psychological Association (APA). The protocol was approved by the Bioethics Committee of the Murcia University (ID: 1494/2017). All subjects gave written informed consent in accordance with the Declaration of Helsinki [27].

2.2. Measurement Instruments

Socio-demographic questionnaire. In terms of sample description, the previous questions cover age, the sport in question, and the level at which it was practiced together with the number of training sessions per week.

Perfectionism. We used the Multidimensional Perfectionism Scale adapted and validated for the Spanish context by Carrasco et al. [8] from the original Frost Multidimensional Perfectionism Scale (FMPS; [28]) to measure perfectionism. The scale includes 35 items that converge into four first-order factors (Expectations of Achievement, Organization, Fear of Mistakes, and External Influences), two second-order factors (Adaptive Perfectionism and Unadaptive Perfectionism), and one third-order factor (Global Perfectionism). The responses were distributed on a Likert scale from 1 (in total disagreement) to 5 (in complete agreement). This study analyzed the third order structure, and we obtained consistent sample reliability (Table 1); Cronbach's Alpha was 0.87.

Anger expression and management. We used the State-Trait Anger Expression Inventory for Children and Adolescents (STAXI-CA) adapted and validated by Del Barrio, Aluja, and Spielberger [29] for Spanish children and adolescents from the original State-Trait Anger Expression Inventory for Adults (STAXI; [30]) in order to measure anger expression and management. This inventory includes 32 items converging in three first-order factors and two second-order factors: state anger (feeling "I'm furious" and physical and verbal expression "I feel like cursing"), anger trait (temper "I am bad-tempered" and reaction "it makes me angry to be late because of the others"), and anger expression (internal expression "I hide my feelings", external expression "I show my anger", and anger management "When I lose control, I can restrain myself"). The responses were distributed on a 1–3 Likert scale, whose limits are little and a lot. This study obtained sample reliability; Cronbach's alpha was 0.79.

Self-esteem. The Rosenberg Self-Esteem Scale (RSS) adapted and validated by Martín-Albo, Núñez, Navarro, and Grijalvo [31] was applied to the Spanish population for the global measurement of self-esteem from the original Rosenberg Self-Esteem Scale (RSES; [32]). This scale consists of ten items (five positive and five negative). The participants scored their level of agreement with each item, using a Likert scale and four alternatives ranging from 1 (strongly disagree) to 4 (strongly agree). Cronbach's alpha for this sample was 0.71.

Table 1. Descriptive statistics of the sample.

	α
Perfectionism	0.87
Organization	0.87
Personal standards	0.74
Fear of making mistakes	0.76
External expectations	0.78
Anger Expression	0.79
Trait anger	0.72
State anger	0.87
Anger management	0.87
Self-Esteem	0.71

2.3. Procedure

A protocol of action was drawn up in order to proceed in the same way in each of the sports environments. First, an interview was scheduled with the coach, technician, or manager of the Federation or Club in question in order to request the necessary authorization to administer the set of questionnaires. Once the permission was granted, a visit was agreed to, always during training sessions. Since group administration was prioritized, the protocol applied was as follows: (a) an explanation of the objectives of the study; (b) expected results; and (c) to protect anonymity, participants gave consent and were given confidentiality and anonymity in accordance with the ethical guidelines of the American Psychological Association (APA). All participants were asked for an informed consent signed by the parents/guardians, which detailed the main characteristics of the study, the relevance of the data for the improvement of existing knowledge, as well as compliance with privacy and ethics norms [27]. Subsequently, each athlete received a full and numbered questionnaire, and an evaluator was always present to solve potential doubts.

2.4. Data Analysis

Data coding and processing was carried out using SPSS Statistics 22.0 for Windows. Perfectionism profiles of the sample were established by segmenting scores in personal standards and evaluating concerns according to the Kolmogorov–Smirnov test and categories 2 × 2 model. We carried out internal reliability analyses of the measures used (Cronbach's alpha), a descriptive analysis (mean and standard deviation), comparative measurements (Student´s t-test and Cohen´s d for effect size), and the Kolmogorov–Smirnov test for normality. A stepwise multiple regression for the predictive relationships by level of self-esteem (Dependent Variable: anger dimensions; Independent Variable: perfectionism) was carried out; finally, univariant analysis of variance (ANOVA) over anger expression variables and self-esteem, according to perfectionist profiles (under 2 × 2 Perfectionism Model), was carried out.

3. Results

Table 2 shows the descriptive statistics (mean and standard deviation) together with the normality tests of the variables studied. The Kolmogorov–Smirnov test shows that the variables follow a normal distribution, thus allowing the use of parametric tests. Statistically significant differences between athletes with low and high self-esteem were obtained for personal standards and fear of making mistakes. Furthermore, the high self-esteem category shows that the mean scores of the personal standard dimensions and anger management have higher values when compared to the low self-esteem category.

Table 2. Descriptive statistics of the sample.

	K–S	High Self-Esteem		Low Self-Esteem		p	d
		M	SD	M	SD		
Organization	0.20	27.49	6.13	27.71	6.60	0.72	−0.03
Personal standards	0.20	21.74	5.42	19.75	5.50	0.00 **	0.36
Fear of making mistakes	0.20	24.10	6.55	28.07	6.89	0.00 **	−0.59
External expectations	0.20	20.93	5.60	21.54	5.80	0.30	−0.63
Trait anger	0.20	12.98	3.03	13.67	2.99	0.12	−0.22
State anger	0.20	9.33	1.92	9.49	2.04	0.70	−0.08
Anger management	0.20	15.42	3.75	14.95	3.73	0.22	0.12

Note: K–S = Kolmogorov–Smirnov; M = Mean; SD = Standard deviation, ** $p > 0.01$.

In Table 3, the results of the predictive analysis show that low personal standards and a high orientation towards organization predicts state anger when there is high self-esteem. By contrast, high personal standards predict anger management when self-esteem is high, while low personal standards predict anger trait when self-esteem is low.

Table 3. Linear regression analysis (stepwise).

	Dependent Variable	Predictive Variable	R	β	t	p
Low self-esteem	Trait anger	Step 1: Personal standards	0.20	−0.20	−0.01	0.04 *
High self-esteem	State anger	Step 1: Personal standards	0.21	−0.21	−2.47	0.01 *
		Step 2: Personal standards organization	0.28	−0.24 0.18	−2.82 2.18	0.00 ** 0.03 *
	Anger management	Step 1: Personal standards	0.22	0.22	2.65	0.00 **

Note: * $p > 0.05$; ** $p > 0.00$.

In Table 4, the results of the ANOVA analysis show differences according to personality profiles in anger state (F = 3.42; p = 0.01) and self-esteem (F = 8.01; p = 0.00). The highest average score in anger state occurs in maladaptive perfectionism, while the lowest average score occurs in adaptive perfectionism. On the other hand, it is possible to highlight the same in self-esteem and average scores according to perfectionism profiles.

Table 4. Analysis of variance (ANOVA) according to perfectionist profiles (Gaudreau and Thompson, 2010).

		Non-Perfectionism	Mixed Perfectionism	Adaptive Perfectionism	Maladaptive Perfectionism	F	p	η
Anger management		15.07 (4.31)	15.29 (3.31)	15.57 (3.87)	15.12 (3.15)	0.17	0.91	0.00
Anger	State	9.13 (1.72)	9.75 (2.20)	8.79 (1.46)	9.87 (2.20)	3.42	0.01 *	0.04
	Trait	12.90 (3.20)	13.40 (2.84)	13.47 (2.84)	13.44 (3.05)	0.50	0.67	0.00
Self-esteem		32.31 (3.74)	31.30 (4.41)	34.11 (3.73)	30.06 (4.06)	8.01	0.00 **	0.09

Note. * $p < 0.05$; ** $p < 0.01$.

4. Discussions

The objective of this research was to assess the differences in a sample of young athletes in terms of anger expression and management according to their level of self-esteem and indicators of perfectionism. In relation to this objective, it is worth highlighting that no other similar study has been published so far, making this study innovative, given that it combines self-esteem, perfectionism, and anger expression variables.

On the basis of the results found, the first hypothesis was confirmed as athletes with high self-esteem had the highest scores in the adaptive perfectionism dimensions, in line with the results in previous research [2]. Specifically, those athletes with high levels of self-esteem had higher scores in the perfectionism sub-dimension of personal standards. These results are in line with previous research in which self-esteem is considered an important mediator between functional perfectionism and other psychological variables [33,34]. It is relevant for an athlete to continue to see him or herself as successful and to accept personal and environmental limitations when there are difficulties in achieving the objectives set. Having the ability to strive to meet a challenge along with the desire to reach it reinforces self-esteem and the possibility of engaging in innovative activities.

The results did not confirm the second hypothesis, in which lower self-esteem scores were expected to relate to dysfunctional perfectionist indicators [2,17] and anger expression. The unadaptive effects of perfectionism in the form of anxiety reactions [35] or lack of emotional control [36] raise, according to the literature, the need to promote balance and work in relation to the self-esteem of young athletes in training processes. This balance involves the socializing agents (family and coach) who are relevant in the development and maintenance of functional perfectionist tendencies; thus, it is necessary to promote and facilitate appropriate response resources in unadaptive sports situations that generate conflicts at the individual level (beliefs or disordered behaviors) and/or social levels [37,38].

Depending on the level of self-esteem, different predictors of perfectionism indicators were found in relation to anger expression and management [21]. In those athletes with high self-esteem, indicators of functional perfectionism turned out to be good predictors of anger control and state anger. Furthermore, personal standards negatively predicted state anger and positively predicted anger management, with the percentage of variance explained by each model being 28% and 22%, respectively. By contrast, athletes with low self-esteem showed that their personal standards negatively predicted trait anger, i.e., recurrent episodes of anger due to perceiving a series of situations as provocative (e.g., competitive situations).

Finally, the results have shown differences in anger and self-esteem scores according to the perfectionist profiles in the model of Gaudreau and Thompson (2010). The results confirmed the third hypothesis, identifying a positive significant relationship between personal standards and self-esteem [17] and anger [39]. By contrast, the results confirmed the fourth hypothesis, confirming previous research and identifying a positive significant relationship between evaluative concerns and anger [39,40]. As a result, mixed or maladaptive perfectionist athletes may have a greater predisposition to experience feelings such as anger as a consequence of their frustrated expectations and their tendency to judge themselves harshly [41,42]. On the other hand, the results have showed that adaptive and non-perfectionist athletes have higher self-esteem scores than other perfectionism profiles. Concern for mistakes is positively associated with the tendency to make internal attributions, while athletes with high personal standards are associated with a greater probability of attributing performance to internal causes and stable elements [17,41].

5. Conclusions

In conclusion, the results show that regardless of low or high self-esteem, if athletes and those around them are able to regulate personal standards, planning, and organization factors, it should be possible to control anger expression [43–45]. Therefore, the functional capacities of an athlete through personal standards and order are better predictors of anger management than external influences exerted by parents and coaches. These findings have made it possible to discover those regulatory mechanisms for an athlete's performance that can promote psychological coping strategies in the face of unknown situations. The study of these types of variables in the sports field will allow sports psychologists to design prevention and/or stimulation of adaptive behavior programs.

In future studies, given the importance of these concepts for young people's development, it will be necessary to conduct research with a sample of female athletes to analyze the moderating effect of different levels of self-esteem on perfectionism and anger management. This is one of the limitations of this study; there were numerous difficulties when it came to getting access to female athletes' samples given that this population had recently participated in another research project. Furthermore, in view of the importance of self-esteem levels on perfectionism indicators and consequently on anger expression and management, it would be useful to have broader, homogeneous samples covering different ages through longitudinal studies to analyze whether there are variations through adolescence. In the same way, the variability of the samples should be generalized to samples of high-performance athletes and any other level of sport, not only those in the early stages of training. To this aim, more sports-specific instruments should be used as well as more complex statistical techniques, such as mediation.

Regardless of these proposals for further research, it is clear that perfectionism includes functional and adaptive aspects based on individual characteristics such as self-esteem, which have an impact on anger management. Thus, a line of research has been opened that can contribute to explaining athletes' behaviors and emotional management in relation to their sports goals, as well as the influence of other hidden psychological variables (individual and contextual) that may be exerting an important or rather significant effect on athletes' responses, and therefore on their beliefs, their performance, their motivations, and their learning.

Author Contributions: Conceptualization, A.J.M.-V. and J.G.-H.; Methodology, A.J.M.-V.; Software, A.J.M.-V.; Validation, A.J.M.-V.; Formal Analysis, A.J.M.-V.; Investigation, A.J.M.-V. and J.G.-H.; Resources, A.J.M.-V.; Data Curation, A.J.M.-V. and J.G.-H.; Writing-Original Draft Preparation, A.J.M.-V. and M.G.-L.; Writing-Review & Editing, A.J.M.-V., J.G.-H. and M.G.-L.; Visualization, A.J.M.-V.; Supervision, J.G.-H. and M.G.-L. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Effects of a Physical Activity Intervention on Physical Fitness of schoolchildren: The Enriched Sport Activity Program

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Received: 21 February 2020; Accepted: 4 March 2020; Published: 6 March 2020

Abstract: *Background:* Physical fitness in youth is a predictor of health in adulthood. The main objective of the present study was to understand if an enriched sport activity program could increase physical fitness in a population of schoolchildren. *Methods:* In a sample of 672 children aged 10.0 ± 1.90 years, different motor skills were tested by the 1 kg and 3 kg ball throw (BT), the standing broad jump (SBJ), the 30 m sprint (30mS), the leger shuttle run (LSR), the illinois agility test (IGT), and the quadruped test (QT). Within the controlled-trial, the intervention group (ESA) underwent an additional warm-up protocol, which included cognitive enhancing elements, for 14 weeks while the control group continued with ordinary exercise activity. *Results:* A significant increase was present regarding the 1 kg and 3 kg BT, the SBJ, the 30mS, and the IGT, while no significant difference was shown regarding the QT and the LSR in the ESA group between pre and post intervention. In the control group, no differences were present for any test except for the QT and the LSR post-test. *Conclusion:* A 14-week structured physical intervention had moderate effects regarding throwing, jumping, sprinting, and agility in a sample of schoolchildren.

Keywords: fitness tests; schoolchildren; exercise; warm-up; sporting activities; cognitive tasks; inhibition; working memory; shifting

1. Introduction

Physical inactivity is widely recognized as a risk factor for illnesses in adulthood [1–3]. Health-promoting interventions, including enhanced physical activity and exercise programs showed promising results in different life stages [4]. An increase of physical activity is also associated to an increase in physical fitness [5], and such increased level of fitness has a positive effect on health [6]. Physical activity may act by increasing the functional capacity of the cardiovascular system, increasing nervous plasticity and musculoskeletal efficiency, which will have widespread positive effects on the health of human beings [7,8].

Different exercise activities represent an effective strategy to increase motor competence, targeting various components of the individual, such as aerobic, anaerobic, dual task, and motor coordination [9]. Another aspect regarding the effects of exercise, is the relation between physiological and psychological health [10], which underlines that cognitive functions play a role in maintaining and promoting health [11]. There is an increase in cognitive functioning and mental health and wellbeing [12] following exercise, especially in children, in which such activities are linked to neuroplasticity [13]. Three main cognitive functions have been seen to increase following physical activities: inhibition, working memory and shifting [14]. An example of such phenomenon can be seen either regarding structural adaptations, such as increase of the brains gray matter and volume [15,16], an increase in the level of neurotrophins [17], and increased brain blood flow [18]. Also, functional adaptations, such as modifications in the neuronal network [19], which have also been seen to increase academic achievement [20] and improve memory and attention [18,21] can be found. Hence, poorer fitness levels correlate to poorer cognitive abilities [22]. However, such increase in cognitive functioning has been seen to be greater in those populations with a poor physical fitness level or those displaying mental or physical disabilities [23]. The majority of the studies linking the increase in neuroplasticity and cognitive function towards exercise tend to consider aerobic exercise as the primary form of exercise modality able to influence cognitive function [13,18,21]. Vice versa, limited evidence is available, explaining the possible mechanisms able to increase physical fitness through the implementation of cognitive-oriented tasks.

A thoroughly studied aspect, however, is coordination. Jensen et al. [24] reports the effects of a coordination-enhancing protocol on spatial cognitive tasks, concluding that such training may be useful to individuals who use spatial cognition in their working activities. Furthermore, Chang et al. [25] studied the effects of coordination training in pre-school children on event-related potentials. These variables provide a measure of the brain's response to external stimuli. After an 8-week intervention, an increase in the pre-frontal cortex activity was remarkable, highlighted by increased P3 amplitudes waves and reduced reaction times on a flanker task. Both studies underline the possibility that specific types of coordination training influence aspects of cognitive function. Besides, Roebers et al. found that the influence of 9-month coordination training on motor skill development in children aged 5-6 years accentuated an increase in motor skills linked to cognitive performance [26]. A positive correlation of coordination towards strength has also been evaluated [27]. Coordination tasks incorporated into strength training promote a moderate increase in isometric strength. Moreover, the participants of the study of Rutherford and Jones lifted significantly more weight during the required task.

Within the intervention of the ESA project, namely the Enriched Sport Activity program, we aimed to integrate physical and cognitive tasks through an enriched sport activity program, which mainly included coordination exercises as a form of an additional warm-up, before regular sporting activities [28]. The aim of this study is to understand the effects of an enriched sports activity program intervention that includes cognitive-enhancing elements to physical fitness in a sample of children from seven European countries.

2. Materials and Methods

2.1. Participants

The ESA program is an evidence-based exercise program cofounded by the Erasmus + Program of the European Union (Key action: Sport-579661-EPP-1-2016-2-IT-SPO-SCP). In order to understand the effects of ESA, a sample of 672 children aged 10.0 (± 1.9) was selected from seven participating countries of the program (Italy, Germany, Turkey, Spain, Lithuania, Croatia, and Portugal) [28]. The sample was composed of 379 boys and 293 girls (Aged 10.2 ± 1.8 and 9.8 ± 2.0, respectively) who were allocated in an ESA or control group (n = 368 and n = 304, respectively). All children were healthy and free of any disability or musculoskeletal, cardiological, neurological or respiratory diseases or dysfunctions. Before the inclusion of the children in the ESA program, a parent or legal representative of each child signed an informed consent. The study was conducted in accordance with the Helsinki Declaration (Hong Kong revision, September 1989) and the European Union recommendations for Good Clinical Practice (document 111/3976/88, July 1990). The Lithuanian Sports University's Research Ethics Committee in Social Sciences approved the study with No 98 579661-EPP-1-2016-2-IT-SPO-SCP (2018-02-05).

2.2. Study Design

The participants completed a baseline (t1) and post-test evaluation (t2), which consisted of a 1 kg and a 3 kg ball throw (BT), a standing broad jump (SBJ), a 30 m sprint test (30mS), an illinois agility test (IGT), a quadruped test (QT), and a leger shuttle run test (LSR). Each test assesses different components of physical fitness [29]. The schoolchildren performed the LSR and IGT test once and the other four tests three times, of which the best result was considered in the analysis. The children conducted the tests in a random order. After t1, the children were randomly assigned to the ESA or control group, respectively. The ESA group underwent the ESA program, performing exercises linked to executive cognitive functioning, in particular, inhibition, working memory, and shifting, rather than performance-enhancing tasks. These tasks were carried out for 14 weeks, divided in 27 different training units implemented during a warm-up of a duration of 15 to 25 min prior to each participant's structured physical activity [28,30]. The warm-ups were structured into a baseline phase that could last up to 10 min, and a stimulation phase which could last up to 15 min. The innovation introduced by the program consists of standardization of the warm-up sessions, enriched by cognitive stimuli, through the introduction of propaedeutic exercises that are suitable for several sports activities. The control group instead, did not undergo the ESA intervention and continued with each own regular exercise or PE. After the interventions period, the participants were re-evaluated.

2.3. Intervention Procedure

Before the start of the project, each participating coach received training regarding testing procedures and training modalities. The training for each coach was individually carried out by each country adhering to the project. Training procedures and modalities were standardized and shared by each country. The training had a duration of 8 h, delivered within a single day, which comprised a theoretical and a practical part. The ESA program had a duration of 14 consecutive weeks in the context of schools and sport centers. The intervention involved children from 7 to 14 years of age who were physically active. The protocol consisted of an additional warm-up performed before the practiced PE of each participant. The participants of both the ESA and control group were children regularly practicing school physical education or different sporting activities such as basketball, soccer, handball, and volleyball. Therefore, the ESA group added the following procedure (the ESA program) to the practiced physical activity, while the control group did not. The control group continued practicing his/her activity without the additional warm-up phase. For each school or sporting center, there were children allocated in the ESA or control group. The trainer of both groups for each school or sport center was a trainer of the ESA program. The ESA program consisted of 27 units, each unit had a maximum duration of 25 min divided in a twofold phase: a baseline and a stimulation phase. The enriched activity was obtained by introducing stimuli belonging to both the cognitive and motor domain.

The cognitive elements for the stimulation phase could involve inhibitory control, working memory, or task-shifting skills. For inhibitory control, the coach gave verbal commands of an exercise to which corresponded the execution of another movement, before being associated. Concerning working memory, the coach orally explained an exercise series, and the child had to execute the exercise in reverse order. Regarding task shifting, the child performed the exercises following the instructor's command, but when the instructor whistled, the athlete had to pass the ball to the child ahead. Concerning the validity of the proposed exercises, four internal experts (two sport scientists and two psychologists) qualitatively rated the exercises relatively to the congruence with the proposed executive function. All the discrepancies among their judgments were solved through discussion or the modification of the exercise, until an agreement was reached, before the start of the project.

The instructor had to whistle between three and five times for each circuit, allowing the athlete to vary at least once each exercise. For every domain, children had to complete a beginner level (B), then an intermediate level (I), and finally, an advanced level (A). Each level was composed of nine units. A series of coaches' guidelines video-tutorials were recorded to maximize the protocol standardization across the European administrators.

2.4. Measures

One kilogram and 3 kg ball throw: The participant sat on the ground with the back against the wall and legs extended and apart. A valid straightforward throw of the medicine ball was performed by a quick extension of the upper limbs in full-range of motion parallel to the ground. The zero-end of the yardstick should be placed on the chest. Operators measured the distance between the zero-end of the yardstick on the chest and the landing point of the ball, detected by another operator, using a standard tape measure, to the closest 1 mm, from a line passing between the chair's frontal legs to the point the ball landed touching the ground. The protocol required three attempts with the 1 kg and the 3 kg medicine ball each. The procedure was identical for the 1 kg and 3 kg ball.

Standing Broad Jump: The SBJ test was performed on a hard surface. The participants were in a standing position with heels on the starting line and feet parallel. The participants had to jump as far as possible in a horizontal direction. No indication had been given on the movement of the legs or the arms, so, the participants could perform a self-decided depth countermovement of the legs and perform a free-arm amplitude swing. The participants had to land with both feet together and block the jump without further advancement. The distance was measured using a standard tape measure, to the closest 1 mm, from the starting line to the heel of the closest foot to the starting line.

Thirty meter Sprint test: Participants were standing in a flying start position with both feet behind the starting line. The first operator (placed at the athlete's back) gave the "ready" command (start command) and clapped his/her hands. After the start command, the athlete sprinted at maximum speed for 30 m. The second operator standing near the finish line started the stopwatch the moment the participant moved the rear support foot, and stopped it the moment the participant's torso passed the finish line. The fastest time required to complete the task was considered for investigation. The measure was calculated through a regular stopwatch, measured in seconds to the nearest second decimal.

Illinois agility test: The standard procedure for the IGT was adopted [31]. The protocol consisted of a testing space of 10×5 m marked with cones, with four center cones spaced 3.3 m apart and four corner cones positioned 2.5 m from the center cones. The participant laid on the ground, hands by the shoulders, and all body parts behind the starting line. An operator (placed at the athlete's back) gave the "ready" command (start command) and clapped his/her hands. After the start command, the participant got up quickly and ran through the course. At the finish line, the second operator recorded with a regular stopwatch, in seconds to the nearest second decimal, the time passed between the clap of hands and the moment in which the athlete's chest passed the finish line.

Quadruped test: The participant was in all-fours position with both hands on the ground and the buttocks high in the air behind the starting line. An operator (placed at the athlete's back) gave the "ready" command and clapped his/her hands. After the start command, the participant quickly proceeded forward, for a total distance of 10 m, alternating the diagonally opposite upper and lower limbs, e.g., right hand and left foot, and took steps until touching the finish line with one hand. The second operator waiting near the finish line started the stopwatch with a clap of hands and stopped the moment the participant touched the finish line with one hand. The measure was calculated through a regular stopwatch, in seconds to the nearest second decimal.

Leger shuttle run test: The standard procedure for the LSR was adopted [32]. At the "go" of the instructor, the participant had to run between two lines set 20 m apart at a pace dictated by a recorded tone at appropriate intervals. Velocity was 8.5 km·h^{-1} for the first minute, which increased by 0.5 km·h^{-1} every minute thereafter. The test was completed when the participant was not able to keep the rhythm, not arriving at the cones, two times in a row. Operators ensured that the participant correspond to the pace within the two beep signals. The number of stages was recorded, and the total number of completed stages was retrieved for investigation.

2.5. Statistical Analysis

Means and standard deviations were described for the total sample and for both the ESA and control groups. All data has been tested for normality using the Kolmogorov–Smirnov test. Since the data appears to be not normally distributed, non-parametric evaluation has been carried out. In order to identify differences between groups, the U-Mann Whitney test for unpaired data has been performed, whereas to identify differences within groups, the Wilcoxon Test for paired data has been performed. Cohen's d, to estimate effect sizes, were also calculated. All tests were carried out with IBM SPSS Statistics (Version 25, IBM Corp., Armonk, NY, USA). Significance level was set to $p < 0.05$.

3. Results

Table 1 provides descriptive measures of the sample for boys, girls, and both groups. The table also reports means and standard deviations of t1 and t_2 of both the ESA and control group, respectively.

Table 1. Descriptive characteristics of the sample.

Variable	ESA	Control	Total	
n	368	304	672	
	Boys	Girls		
n	379	293	672	
Age	10.2 ± 1.8	9.8 ± 2.0	10.0 ± 1.9	
Tests	**ESA t1**	**Control t1**	**ESA t2**	**Control t2**
1 kg BT (m)	3.00 ± 0.8	3.27 ± 1.2	3.22 ± 0.9	3.48 ± 1.3
3 kg BT (m)	1.93 ± 0.5	2.17 ± 0.7	2.05 ± 0.5	2.26 ± 0.8
SBJ (m)	1.38 ± 0.2	1.40 ± 0.3	1.44 ± 0.2	1.42 ± 0.3
30mS (s)	6.11 ± 0.8	6.17 ± 1.0	6.02 ± 0.9	6.20 ± 1.2
IGT (s)	21.2 ± 3.9	20.5 ± 5.5	20.8 ± 4.1	20.2 ± 5.3
QT (s)	6.7 ± 4.1	7.9 ± 5.1	5.9 ± 2.2	5.8 ± 2.4
LSR (stage)	33.1 ± 14.9	29.9 ± 16.8	35.6 ± 16.3	35.5 ± 19.4

The intervention group (ESA); ball throw (BT); standing broad jump (SBJ); 30 m sprint test (30mS); illinois agility test (IGT); quadruped test (QT); leger shuttle run test (LSR); m = meters; s = seconds.

Differences between conditions have been calculated for each test at t1. No difference was observed for any test except for the QT and LSR ($p < 0.05$, d 0.27 and $p <$ 0,001, d −0.19, respectively). After the intervention, a significant difference in the performance measures of the 1 and 3 kg BT ($p = 0.003$, d −0.27 and 0.008, d −0.22, respectively), in the SBJ ($p = 0.001$, d −0.23), the 30mS ($p = 0.014$, d 0.11) and the IGT ($p = 0.0112$, d 0.12) in the ESA group was observed. No difference was present in the OT test and the LSR ($p = 0.276$, d 0.01 and $p = 0.821$, d −0.18, respectively). An opposite trend was seen in the control group in which no difference was observed in the 1 and 3 kg BT ($p = 0.073$, d −0.18 and $p = 0.275$, d −0.11, respectively), in the SBJ ($p = 0.625$, d −0.05), the 30mS ($p = 0.692$, d −0.01) and the IGT ($p = 0.162$, 0.06). However, a significant change was present in the QT and the LSR ($p < 0.001$, d 0.12 and $p = 0.001$, d −0.30, respectively). Table 2 presents statistical differences between t1 and t2 of both the ESA and control Group. No differences were present at t2 between conditions for any test.

Table 2. Statistical differences between t1 and t2 of both the ESA and control group.

Tests	ESA	Control
1 kg BT	0.003 *	0.073
3 kg BT	0.008 *	0.275
SBJ	0.001 *	0.625
30mS	0.014 *	0.692
IGT	0.011 *	0.162
QT	0.276	<0.001 *
LSR	0.082	0.001 *

Wilcoxon test for paired data was performed. * significant $p < 0.05$.

4. Discussion

Our study aimed to understand the effects of an enriched sport activity program in the form of a structured warm-up with different levels of difficulty on physical fitness in a population of children. Our main results suggest that the fitness tests proposed increased their measure, whereas no increase was present in those tests pertinent to coordination and aerobic fitness. Conversely, the control group increased only in the coordination and aerobic fitness tests. However, little to no effect was present in both the ESA and control group between t1 and t2. The results obtained suggest that from a perspective of motor performance, the ESA activity does not produce highly significant effects. Therefore, the results are similar to those obtained from a regularly practicing physical activity group.

The ESA program at this stage is a first approach of an experimental exercise-based approach that aims to promote cognitive activity. Notwithstanding the fact that the observed effect does not provide a large magnitude, no negative effects within the intervention group were observed.

The level of physical activity has been well established to influence the level of physical fitness [33], and a physical activity dose-response has been inversely associated to health risk outcomes. In accordance, our results highlight that the majority of the tests proposed increased their measure, which can translate to an increase of the general physical fitness. The form of increased activity which was administered in this project was through structured warm-ups prior to each children's ordinary activity. There have been various attempts to evaluate the influence of specific warm-up protocols on performance. A study by Yanci et al., [34] evaluated three different duration warm-up protocols (8, 15 and 25 min) in soccer players, highlighting that longer duration protocols were associated to an increased perceived exertion before the physical performance. A performance reduction was also observed during a 10 m sprint and no difference from the baseline evaluation was evinced in a modified agility test. This may provide an explanation regarding the results of the QT, which has also been proposed for a distance of 10 m. Comparably, neither of the test measures provided for our test show an increase after the intervention period. Another study has evaluated the influence of specific and general warm-ups on explosive muscular performance [35], resulting that only those pertinent to explosive strength provided additional value to the muscular outcomes. This aspect has also been highlighted by van den Tillaar et al., [36], who also stressed that during a warm-up, specificity should be preferred rather than duration. There may be a twofold explanation on why the LSR did not show an increase in the ESA group: Firstly, no specificity was provided regarding aerobic activity. Secondly, the duration of the warm-up activity was too long causing negative effects on the aerobic outcomes in the sampled population. Therefore, coaches should not provide excessively long warm-ups [36].

The implementation of the intervention was not controlled. This fosters the need for high-quality process-evaluation measures to assure the effectiveness of the ESA program intervention. However, our results may provide insight for future studies regarding our testing procedures.

The present study is not without limitations. During the intervention period, the school children all regularly practiced a sport activity. The different training schedules (volleyball, basketball, soccer, and handball) in both the ESA and control groups may influenced the test results. Furthermore, we did no control for age-related influences, which may have affected the outcome measures. We want to point out that this study provides a tentative interpretation of intervention effects on physical fitness, since it remains unclear if the improvement of physical fitness evinced in the ESA group is due to the benefits of the ESA program, due to the regular exercise practiced, or for the developmental phase of the participant's life. Finally, the validity of the enriched activities was controlled only from a qualitative point of view. Such limitations may represent important information for future projects that will aim to use exercise-based approaches to implement cognitive activities.

To our knowledge, this is the first study to evaluate the effects of an additional structured warm-up session to ordinary sport activities in children. For this reason, we believe it is important to consider these data as a starting point, notwithstanding the small effects provided. Further application of the test battery would establish the research methodology and enhance the normative comparability of the sample. The ESA program has provided a tool that can be included in physical education classes or sport facilities as a strategy to promote physical fitness through coordination exercises and cognitive-enhancing elements. Another aspect that needs to be considered is that during the entire period of the ESA program (14 consecutive weeks), no children were either injured due to the proposed activity nor dropped out due to excessive training intensity, also reporting a generally high level of enjoyment. The ESA intervention is an easy-to-administer, enjoyable strategy to further promote physical fitness, which can be incorporated in a variety of sport activities and exercises of children.

5. Conclusions

The present study shows that an enriched sport activity, in the form of structured warm-ups, in addition to each children's practiced physical activity, was able to promote some aspects of physical fitness among schoolchildren. The results obtained by the children who underwent the ESA intervention are in line with those that were regularly practicing physical activity.

An additional warm-up protocol may represent an effective strategy to include in ordinary workouts in order to promote physical fitness in youth. In conclusion, our methodology is the first structured exercise-based approach to include cognitive-enhancing elements for inhibition, working memory and shifting during other physical activities.

Author Contributions: Conceptualization, A.B.; Data curation, A.B., F.N.Ş. and Ö.G.; Formal analysis, E.T.; Investigation, G.T., C.M.d.S., M.B., M.G., S.P. and I.J.Z.; Methodology, N.L., M.G.-L. and G.F.L.S.; Project administration, M.A. and A.P.; Supervision, M.B. and M.G.; Visualization, A.R.; Writing—original draft, E.T.; Writing—review & editing, A.B. and D.J.S. All authors have read and agreed to the published version of the manuscript.

Funding: The work was conducted within the ESA (Enriched Sport Activities) Program—Agreement number 2016-3723/001-001, funded by the Erasmus Plus Sport Programme (2017–2019) of the European Commission. Erasmus+ Sport Programme. EAC/A04/2015 – Round 2 E+ SPORT PROJECT: 579661-EPP-1-2016-2-IT-SPO-SCP. Enriched Sport Activities Program.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Mexican Validation of the Engagement and Disaffection in Physical Education Scale

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Received: 29 December 2019; Accepted: 5 February 2020; Published: 11 March 2020

Abstract: To date, no instrument adapted and validated that measures engagement and disaffection in the physical education class has been found, which limits the generation of knowledge of this area in Mexico. The aims of this study were to translate and adapt the engagement and disaffection scale to the context of physical education in Mexico and to examine its reliability, structure (two and four factors), and factorial invariance by gender in Mexican fifth- and sixth-grade elementary school students. A total of 1470 students participated (50.6% boys) with ages between 10 and 14 years (mean (*M*) = 10.56; standard deviation (*SD*) = 0.77) from federal (89.3%) and state (10.7%) elementary schools. Two factorial structures were tested (with four factors and two factors). The fit indexes of both models were satisfactory, and the factorial saturations were significant. The differences between the fit indexes of both models were irrelevant; therefore, the two-factor model was considered more suitable. The total strict invariance by gender was confirmed, and the reliabilities of the engagement and disaffection scale were acceptable. The Mexican version of the course engagement and disaffection scale in physical education is valid and useful to measure these constructs in the context of physical education in Mexico.

Keywords: engagement; disaffection; physical education; invariance; gender; Mexico

1. Introduction

Within the education context, engagement is seen as a malleable state that is influenced by different processes, like the school's, teacher's, parent's, and classmate´s ability to provide constant support to achieve learning [1–4]. It is an active image that represents learning through the effort and interaction with the teacher; in other words, it is both an individual and a context issue.

Research regarding engagement in the school context has a background and consequences similar to those found in the labor context, such as self-efficacy, autonomy, social support [5], optimism, and hope [6]. In addition, it is believed that it is especially important for apathetic and discouraged students and those with a high risk of abandoning [7]; therefore, it is an elemental concept to understand the phenomenon of desertion, as well as to promote a successful educational path [8].

These findings highlight the importance of examining academic engagement as an indicator of wellbeing in student populations, as well as a motivational agent for promoting positive consequences, such as performance and learning [9]. However, in the understanding of this engagement construct, there are two important areas that generate confusion. The first focuses on the lack of a clear distinction between indicators (characteristics that belong to engagement itself) versus facilitators (factors outside of the construct that are thought to influence engagement), and the second refers to the number and nature of the dimensions within the engagement; in other words, how many should be distinguished and if they have internal dynamics.

In the scientific literature, there are different theoretical approaches and conceptualizations regarding engagement [10]. Some state that it is a meta-construct that is composed of multiple dimensions on the participation in school [11]. Others emphasize the mental state related to the study of activities [5]. Both models focus on the components of engagement. However, the model by Fredricks, Blumenfeld, and Paris [11], also called the North American model, proposes that engagement is composed of three dimensions: behavior, emotion, and cognitive. On the other hand, the model by Schaufeli, Salanova, Gonzalez-Romá, and Bakker [5], also known as the European concept of engagement, proposes that three dimensions characterize engagement: absorption, vigor, and dedication.

Skinner, Furrer, Marchand, and Kindermann [12] proposed a bipartite model of engagement (E) composed of two dimensions: emotional and behavioral, which are closely linked in the classroom; that is, they are inter-individually stable and are formed in the same way by external factors without influencing each other. Theories such as the Self-Determination Theory (SDT) [13,14] support this conceptualization by suggesting that emotions feed behaviors in the classroom; in other words, emotional engagement, such as interest and enthusiasm, feed behavioral engagement, such as effort and persistence.

Emotional engagement (EE) focuses on the states that are relevant to the emotional participation of the students during learning activities, such as enthusiasm, interest, and enjoyment. On the other hand, behavioral engagement (BE) includes the effort, attention, and persistence during the initiation and execution of learning activities [15]. Engagement in itself combines both dimensions and refers to active interactions, oriented towards objectives: flexible, constructive, persistent, focused, and emotionally positive, with the social and physical environments. In this case, the activities of the physical education (PE) class. Therefore, academic engagement refers to what you want to generate in students through the school context.

In this study, the conceptualization of engagement used by other authors [12,16–18] will be used, as well as the approach of negative engagement referred to in the literature as disaffection [19,20].

Disaffection (D) occupies the negative pole of the engagement continuum and refers to the occurrence of behaviors and emotions that reflect motivational states of poor adaptation [18].

Like engagement, disaffection is composed of the emotional dimension (ED), which includes boredom, anxiety, and frustration in the classroom, and the behavioral dimension (BD), which includes passivity and withdrawal from participation in learning activities [12]. This is because alienation or disaffection probably reflects more than a lack of participation [21]; in other words, when the person does not have the option of abandoning an activity, as normally occurs in school, mental or emotional disaffection can occur [20]. Thus, disaffection is an important source of motivational impotency in children, which impedes achievement in PE [18].

The results of studies in the context of PE have demonstrated the relationship between the student's engagement and academic performance [22], the psychological needs of autonomy, competence, and relationships [23], which, from SDT, are considered as basic and universal for optimal development and growth, as well as for the wellbeing of individuals [24]. Other studies point out the influence of the teacher figure on student engagement. The teacher´s behavior [23] and his or her relationship with their students [25] promote engagement during PE class. Also, extracurricular physical activity is another variable that is directly influenced by engagement and by the perception of student competence in the PE class [26].

These studies demonstrate the importance of measuring engagement as an integral part of any education system since the results obtained from this type of study will serve as very useful indicators in classrooms and be of great value for future scientific research, as well as for the early detection of disinterest and educational abandonment, which will be the objectives of interventions aimed at increasing students' engagement to school and learning.

To date, no instrument adapted and validated to the Mexican context that measures engagement, disaffection, and their respective dimensions in the PE class has been found. This has limited the generation of knowledge of this area in Mexico, and, given the positive relationship that exists between engagement with the PE class and the amount of physical activity that is carried out outside of school [26], studies in this area could contribute to reducing the high rates of physical inactivity that exist in the Mexican population from an early age [27]. Therefore, the objective of this study is to translate the School Engagement Scale of Chi, Skinner, and Kindermann [28] into Spanish and adapt it to the context of PE in Mexico, examining its psychometric properties, structure, and factorial invariance by gender in a sample of Mexican fifth- and sixth-grade elementary school students from the metropolitan area of Monterrey, Nuevo Leon Mexico.

2. Materials and Methods

2.1. Study Design and Sample Description

This was a cross-sectional, descriptive, correlational study. This study involved 1470 students (boys = 50.6% and girls = 49.4%) from fifth (49.3%) and sixth (50.7%) grade from 46 public elementary schools (federal = 89.3% and state = 10.7%) in the metropolitan area of Monterrey, Nuevo León, Mexico, with ages from 10 to 14 years (mean age (M_{age}) = 10.56; standard deviation (*SD*) = 0.77; median = 11) who attended PE class twice a week with a duration of 50 minutes per session, and in which 68% said they practiced at least one sport outside of school. To select the participants, a convenience sample was used considering both gender and grade. Fifth- and sixth-grade students were chosen because children who belong to the final stage of childhood and early adolescence are at the highest level of cognitive development and will not have any complications when responding to the instruments [29].

2.2. Instrument

To measure student engagement and disaffection, the Course Engagement and Disaffection Scale (CEDS) [28] was translated and adapted to the context of PE in Mexico. The scale is composed of 12 items grouped into four dimensions: behavioral engagement (BE), emotional engagement (EE), behavioral disaffection (BD), and emotional disaffection (ED). Each one of these indicators was measured by 3 items. The instrument has as a heading "On a Likert scale from 1 (False) to 5 (True), tell us how true each of the following statements is in reference to the physical education classes" ("*En una escala del 1* (*Falso*) *al 5* (*Cierto*), *dinos qué tan ciertas son las siguientes afirmaciones referentes a las clases de educación física*"). One example of the BE is "I pay attention in the physical education class" ("*Pongo atención en la clase de educación física*") and of the EE, "I enjoy the time I spend in the physical education class" ("*Disfruto el tiempo que paso en la clase de educación física*"). On the other hand, one example of BD is "I only do enough to pass the physical education class" ("*Sólo hago lo suficiente para pasar en la clase de educación física*"), and of ED "The classes of the physical education teacher are very boring" ("*Son muy aburridas las clases del profesor de educación física*"). These items can be grouped in a broader sense where the average of the BE and the EE form the engagement factor (E); on the other hand, the average of the items of the BD and ED form the disaffection factor (D).

2.3. Procedure

This study was carried out according to the ethical guidelines recommended by the American Psychological Association (APA). Authorization was requested in writing from the school zone authorities and from each of the principals of the schools explaining the objectives of the research and the procedure that would be performed together with a model of the instrument. Afterward, authorization was requested for application from the teachers of each group and from the selected students taking into consideration the inclusion criteria: be a regular student in their respective group, regularly have PE class at least twice a week, be voluntarily willing to complete the questionnaire, and deliver the informed consent to participate in the research signed by their parents or tutors. The students were informed of the objective of the study, their willingness to volunteer, the absolute confidentiality of their answers, and the management of the data. They were also told that there were no correct or incorrect answers and they were asked for maximum sincerity and honesty. The questionnaire was anonymous and self-administered collectively in the classroom during school hours. To homogenize the data collection conditions, the administrators received prior preparation and training. The protocol was approved by the Ethics Committee of the Autonomous University of Nuevo Leon (No. 16CI19039021). All subjects gave written informed consent in accordance with the Declaration of Helsinki.

The CEDS was translated into Mexican Spanish following the translation–back translation procedure [30]. The translation was carried out by a professional translation agency hired by the researchers. To adapt the translation to the context of PE, a group of experts was formed with two PhD specialists with previous experience in the validation of psychological instruments, a physical education teacher, and a translator specialized in the area of physical activity and sports, who discussed the discrepancies of the translation until the first version of the Mexican Spanish-language instrument was achieved. This version was retranslated into English by a professional translation agency different from the first, and both versions of the instrument were compared: the original and the translation. The differences in the versions were analyzed again and necessary changes were introduced to facilitate comprehension of the items achieving a final version of each of the scales. This version was administered as a pilot application to a group of 72 students (51.40% boys and 48.60% girls; M_{age} = 10.56; *SD* = 0.78; range = 10–13) of fifth (54.2%) and sixth grade (45.8%) of an elementary school that was not part of the final sample to verify comprehension of each of the items and define the final version. The selection procedure was the same as described in the section of participants and the results of this pilot application did not show any comprehension problems.

2.4. Data Analysis

First, a descriptive analysis was performed for the entire scale and the factors that comprise it. Missing data rates were very small (0.14%) that it was not considered necessary to impute the data. To test the factorial structure of the questionnaire, a confirmatory factor analysis (CFA) was performed of the two proposed models (of two and four factors). Considering the number of response categories of the observable variables ($k \geq 5$) and the values range of skewness and kurtosis (see Table 1), the CFA was performed with the maximum likelihood method and as input, and the polychoric correlation and asymptotic covariance matrix were used.

Model adequacy was analyzed with different fit indexes, such as the Comparative Fit Index (CFI), Non-Normed Fit Index (NNFI), and Root Mean Square Error of Approximation (RMSEA). CFI and NNFI values greater or equal to 0.95 indicate an acceptable fit [31]. For RMSEA, negative values or values equal to or lower than 0.08 are considered satisfactory [32]. The evaluation to determine which of the two models (two and four factors) was a better fit for the values, as well as the factorial invariance by gender, was performed using the differences between the goodness-of-fit indexes of the models. It is assumed that there are irrelevant differences between the models and the factorial invariance between groups if ΔCFI and ΔNNFI ≤ 0.01 [33] and ΔRMSEA ≤ 0.015 [34].

The internal consistency of the instrument and the subscales that compose it were assessed using Cronbach's alpha [35], composite reliability (CR), and the average variance extracted (AVE), as well as a correlation analysis between the factors. The alpha, CR ≥ 0.70, and AVE ≥ 0.50 values are considered acceptable [36]. Convergent validity was analyzed considering that the items had a high burden in their respective construct and the AVE values were ≥ 0.50. Discriminatory validity was examined confirming that the AVE of each construct was superior to the squared correlation between the constructs [36]. The analyses were carried out using the Statistical Package for the Social Sciences (SPSS) V.23 (IBM, Armonk, NY, USA) and the Linear Structural Relations (LISREL) V. 8.80 software [37].

Table 1. The standardized solution of the four sub-scales of the instrument.

	Sub-scales	***M***	***SD***	***Asymmetry***	***Kurtosis***	**Factorial saturations**	
						2 factors	*4 factors*
Engagement		4.10	0.72	−1.10	1.49		
	Emotional engagement	4.21	0.85	−1.26	1.33		
1	I pay attention in my physical education class (*Pongo atención en la clase de educación física*)	4.38	1.01	−1.81	2.76	0.64	0.67
2	I study for my physical education class (*Estudio para la clase de educación física*)	3.25	1.51	−0.35	−1.32	0.24	0.26
3	I try to do the most I can in the physical education class (*Trato de hacer lo más que pueda en la clase de educación física*)	4.35	0.98	−1.62	2.12	0.74	0.80
	Behavioral engagement	3.99	0.82	−0.78	0.49		
4	I enjoy the time I spend in the physical education class (*Disfruto del tiempo que paso en la clase de educación física*)	4.42	1.00	−1.90	3.01	0.77	0.79
5	It is exciting when I make connections between ideas learned in the physical education class (*Es emocionante cuando hago conexiones entre las ideas aprendidas en la clase de educación física*)	4.09	1.14	−1.22	0.72	0.64	0.64
6	The content we see in the physical education class is interesting (*Es interesante el contenido que vemos en la clase de educación física*)	4.12	1.16	−1.28	0.74	0.69	0.69
Disaffection		2.21	1.05	0.72	−0.34		
	Emotional disaffection	1.93	1.20	1.09	−0.07		
7	It is difficult to attend the physical education class (*Es difícil asistir a la clase de educación física*)	2.25	1.50	0.72	−1.04	0.61	0.71
8	I only do enough to pass the physical education class (*Sólo hago lo suficiente para pasar en la clase de educación física*)	2.85	1.60	0.09	−1.56	0.44	0.59
9	I do not do much work outside the physical education class (*No hago mucho trabajo fuera de la clase de educación física*)	2.35	1.48	0.60	−1.12	0.66	0.78
	Behavioral disaffection	1.93	1.20	1.09	−0.07		
10	The classes of the physical education teacher are very boring (*Son muy aburridas las clases del profesor de educación física*)	1.97	1.37	1.10	−0.23	0.86	0.86
11	The physical education class stresses me (*Me estresa la clase de educación física*)	2.00	1.41	1.09	−0.33	0.86	0.86
12	Being in the physical education class is a waste of time (*Es una pérdida de tiempo estar en la clase de educación física*)	1.81	1.34	1.43	0.57	0.90	0.91

Note: M: Mean; *SD*: Standard Deviation. All saturations were significant, $t > 1.96$, $p < 0.05$.

3. Results

3.1. Descriptive Analysis and Normality

The descriptive analysis (mean, standard deviation, asymmetry, and kurtosis) of each of the items, variables, and factors that composed the scale are shown in Table 1. The results reveal higher engagement than disaffection values with PE. Specifically, emotional engagement had higher values in comparison with behavioral engagement, and in the case of emotional and behavioral disaffection, both had the same mean. Most of the asymmetry and kurtosis values were outside the range (−1.5, 1.5), indicating a normal distribution of data [38].

3.2. Confirmatory Factor Analysis (CFA)

The goodness-of-fit indexes of the two-factor, (Satorra-Bentler (SB)χ^2 = 367.58; degree freedom (*df*) = 52; $p < 0.01$; NNFI = 0.971; CFI = 0.977; RMSEA = 0.064) and of the four-factor model (SBχ^2 = 239.34; df = 48; $p < 0.01$; NNFI = 0.981; CFI = 0.986; RMSEA = 0.052) were satisfactory. All of the factorial saturations of the two models were statistically significant ($p < 0.05$).

The differences between the fit indexes of the two models were irrelevant (ΔNNFI = 0.010; ΔCFI = 0.009; ΔRMSEA = 0.012), both models fit similarly, so these results provide support to the most parsimonious model, that is, the two-factor. In addition, the correlation values between the dimensions EE and BE (r = 0.89) and between ED and BD (r = 0.80) in the phi matrix of the CFA were high. This suggests that each dimension group formed only one construct; therefore, the two-factor model was the most adequate.

3.3. Factorial Invariance by Gender

Taking into consideration the results of the previous section, we proceeded to evaluate the structure invariance of the two factors based on gender. Considering the normal distribution of data [38] (Table 1), maximum likelihood was used as an estimation method and covariance matrices, the mean vector, and the asymptotic covariance matrix were used as input for the multi-sample CFA. First, the structure of the course engagement and disaffection scale in physical education (CEDS-PE) was analyzed separately in the sample of boys (Model M0a) and girls (Model M0b). As shown in Table 2, the goodness-of-fit indexes of the models M0a and M0b were satisfactory and all the estimated parameters were statistically significant ($p < 0.01$).

Later, multi-sample analyses were performed creating new nested models. Model (M1) examined the structural invariance in the two groups showing satisfactory fit indexes, which revealed that the factorial structure of the CEDS-PE is invariant between the two groups.

Model 2 (M2) tested the equivalence of the matrix of the factorial saturations through the boys' and girls' group. The goodness-of-fit indexes obtained were satisfactory and the difference obtained between M2 and M1 did not surpass the criterion values; therefore, the invariance in the factorial saturations of the instrument in both samples was confirmed.

Model 3 (M3), which adds the equivalence of the intercepts, showed satisfactory goodness-of-fit indexes. The differences between the goodness-of-fit indexes in the M3 and M1 models did not surpass the criterion values; thus, the equivalence of the factorial saturations and the intercepts was accepted.

Model 4 (M4) added the invariance of the factorial saturations, intercepts, and errors. The results also showed satisfactory goodness-of-fit indexes, and the difference between M4 and M1 did not surpass the criterion values; thus, these results support the strict factorial invariance of the CEDS-PE through gender.

Table 2. Goodness-of-fit indexes of the invariance models.

	Model description	*df*	SBχ^2	RMSEA	(90% CI)	NNFI	CFI	ΔNNFI	ΔCFI	ΔRMSEA
M0a	Baseline Model boy	53	245.547 **	0.070	(0.061–0.079)	0.964	0.971			
M0b	Baseline Model girl	53	199.99 **	0.062	(0.053–0.071)	0.974	0.980			
M1	Structural invariance (Baseline Model)	106	444.020 **	0.066	(0.060–0.072)	0.969	0.975			
M2	FL invariance	116	476.339 **	0.065	(0.059–0.071)	0.970	0.974	0.001	0.001	0.001
M3	FL invariance + Int.	126	498.811 **	0.063	(0.058–0.069)	0.972	0.973	0.003	0.002	0.003
M4	FS Invariance + Int. + Error	138	486.970 **	0.059	(0.053–0.064)	0.976	0.975	0.007	0.000	0.007

Note: *df* = degree of freedom; RMSEA = Root Mean Square Error of Approximation; 90% CI = 90% confidence interval for the RMSEA; NNFI = Non-Normed Fit Index; CFI = Comparative Fit Index; FL = factor load; Int.= intercepts. All comparisons in the Δ indices are made with respect to the baseline model (M1); ** $p < 0.01$.

3.4. Internal Consistency, Correlations, Convergent and Discriminant Validity

The results of the reliability of the instrument are presented in Table 3. The values of Cronbach's alpha, CR, and the AVE are acceptable except the AVE of the variable engagement. In general, these results provide support to the convergent validity of the CEDS-PE. On the other hand, the value of the average variance extracted of engagement and disaffection was greater than the squared correlation between both constructs; therefore, these results support the discriminant validity of the CEDS-PE.

Table 3. Reliability, bivariate correlations, and discriminant validity between the variables of the study.

Dimensions	α	CR	AVE	1	2
1. Engagement	0.70	0.80	0.42	1	0.28
2. Disaffection	0.82	0.87	0.55	−0.53 **	1

Note: ** $p < 0.01$; α = Cronbach's alpha; CR = Composite reliability; AVE = Average variance extracted. The value below the diagonal corresponds to the correlation between the variables. The value above the diagonal corresponds to the squared correlation between the variables.

4. Discussion

In recent years, there has been a growing interest in the school engagement since it has been found that this construct can work as a solution for low academic performance, high levels of boredom and disaffection, and high rates of school dropouts in urban areas [39].

Nevertheless, studies regarding this topic in the Mexican population are still scarce. This could be due to the lack of instruments adapted and validated to the cultural and linguistic context of Mexico; therefore, the aims of this study were to translate the School Engagement Scale of Chi et al. [28] into Mexican Spanish and adapt it to the context of PE, and examine its psychometric properties, structure, and factorial invariance by gender in a sample of Mexican fifth- and sixth-grade elementary school students.

Although engagement is relatively diverse, and researchers have consistently disagreed on the types and number of the dimensions of engagement [11,40–42], it seems that a consensus has been reached that the construct is multidimensional and encompasses different aspects. In the present study, the factorial structure of the Mexican version of the CEDS-PE was evaluated by comparing two factorial models, a two-factor model (engagement and disaffection) and another model composed of four indicators (emotional engagement, behavioral engagement, emotional disaffection, and behavioral disaffection).

Results show that both models presented adequate fit of the data; that is, the instrument can be used to measure engagement versus disaffection or with the behavioral and emotional indicators of each. These results are similar to those of Skinner, Furrer, Marchand, and Kindermann [12] and Skinner, Kindermann, and Furrer [20] in the academic domain with children of fourth to seventh grade in a rural-suburban school of New York. On the other hand, these findings contrast with the Immekus and Ingle [43] findings, which obtained a poor data fit of the two- and four-factor model; however, this study was carried out about the implementation of a project based on English language learning, unlike our study that was conducted for PE class.

With respect to the evaluation to determine which of the two models (two and four factors) was a better fit for the values, results show that differences between the fit indexes of the two models were irrelevant so these results provide support to the most parsimonious model, that is, the two-factor. In addition, the high correlations found in the present study between the behavioral and emotional indicators suggest uniqueness. For this two-factor model, different studies have been successfully conducted in different contexts, like academic [44,45] and PE class [46]. However, these results differ from other studies [12,20,28,47], which support the four-dimension model, since it presented the best fit indexes and moderate correlation values between the behavioral and emotional indicators, that is, in the results of these works, the factors are related but distinguishable from each other.

One of the greatest contributions of the present work was to examine the factorial invariance by gender, which had not been considered in previous studies. Considering the aforementioned results, the model that was tested was the two-factor (engagement versus disaffection). The results of the multi-sample CFA supported the strict factorial invariance through gender; therefore, the CEDS-PE is an instrument that can be used to measure the engagement and disaffection of students towards PE class and to perform comparisons between groups of boys and girls.

The analysis of its internal consistency revealed alpha coefficients that meet the acceptable value of 0.70, recommended by Nunnally and Bernstein [48] and are similar to those obtained in other works [12,20,28,44,45]. In addition, the CR and AVE values of disaffection were above the minimum acceptable criterion and the squared correlation between factors [36]. This supports the convergent and discriminant validity of the two-factor structure of the CEDS-PE (engagement versus disaffection).

This study also has some limitations. This study only includes students from elementary schools in the metropolitan area of Monterrey; therefore, future research to analyze the psychometric properties of the instrument with a population from different school levels and sectors of the country should be carried out. This study presents psychometric support of the Spanish version of the instrument in the linguistic and cultural context of Mexico; thus, the study of psychometric properties with populations from other Spanish-speaking countries could be expanded. It is suggested that studies including the factorial invariance according to grades and school levels, areas and populations of other sectors of the country, as well as populations from different Spanish-speaking countries are performed to determine its function and facilitate the comparison of results. Lastly, we suggested studies that examine the effect of teaching practice, the relationship with peers, parental support, and the value and usefulness given to PE on engagement and disaffection.

5. Conclusions

The results support the two-factor structure (engagement versus disaffection) and the factorial invariance by gender of the Mexican version of the Course Engagement and Disaffection Scale in Physical Education (CEDS-PE), which is a reliable and valid instrument that can be used by teachers, school principals, institutions responsible for education, and researchers to conduct studies to know the levels of engagement and disaffection of students during PE class and make comparisons between boys and girls. In this way, the present study contributes to the generation of knowledge and scientific production in this area in Mexico.

Author Contributions: All authors have read and agree to the published version of the manuscript. Conceptualization, J.Z., R.R.-M., and F.O.-S.; methodology, J.Z.; formal analysis, J.Z. and M.M.-C.; investigation, J.Z. and R.R.-M.; resources, R.M.-S.; data curation, R.B. and R.M.-S.; writing—original draft preparation, J.Z., R.R.-M.; writing—review and editing, R.B., and F.O.-S.; project administration, J.Z.; funding acquisition, J.Z.

Funding: This research was funded by the Fondo Sectorial de Investigación para la Evaluación de la Educación CONACYT-INEE.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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International Journal of
Environmental Research and Public Health

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Shall We Dance? Dancing Modulates Executive Functions and Spatial Memory

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Received: 17 February 2020; Accepted: 12 March 2020; Published: 17 March 2020

Abstract: Background: Aging is generally considered to be related to physical and cognitive decline. This is especially prominent in the frontal and parietal lobes, underlying executive functions and spatial memory, respectively. This process could be successfully mitigated in certain ways, such as through the practice of aerobic sports. With regard to this, dancing integrates physical exercise with music and involves retrieval of complex sequences of steps and movements creating choreographies. Methods: In this study, we compared 26 non-professional salsa dancers (mean age 55.3 years, age-range 49–70 years) with 20 non-dancers (mean age 57.6 years, age-range 49–70 years) by assessing two variables: their executive functions and spatial memory performance. Results: results showed that dancers scored better that non-dancers in our tests, outperforming controls in executive functions-related tasks. Groups did not differ in spatial memory performance. Conclusions: This work suggests that dancing can be a valid way of slowing down the natural age-related cognitive decline. A major limitation of this study is the lack of fitness assessment in both groups. In addition, since dancing combines multiple factors like social contact, aerobic exercise, cognitive work with rhythms, and music, it is difficult to determine the weight of each variable.

Keywords: virtual reality; aging; sport; hippocampus; neuropsychology

1. Introduction

Aging is considered in some studies as one of the most prominent problems in the short and medium term for modern societies [1], demanding more support and investment in health systems. It is widely accepted that normal aging is associated with a decline in brain functions [2], disturbing, among others, executive and memory processes [3].

Spatial memory is reported as one of the most affected abilities by normal and pathological aging, mainly due to the decline of medial temporal lobe-dependent functionality [4]. This cognitive function allows us encoding, storing and retrieving information about spatial locations and stimuli [5].

Until recent years, the assessment of spatial memory skills in humans was inaccurate due to the lack of ecologically valid tests. This issue was solved thanks to technological advancements, which enabled the development of tests that could recreate varied and realistic environments in a more ecological way [6–10]. In this regard, virtual reality based tests allowed to find differences that traditional spatial measurements were unable to report [11,12]. Some tests in this paradigm also proved capable of predicting mild cognitive impairment where traditional measures failed [13].

In addition to spatial memory, executive processes such as inhibition, working memory, and cognitive flexibility, are also disturbed by age-related changes [14]. All these top-down mental processes are needed for mental and physical health, since they allow us to face new situations, solve problems, control our behavior, keep a goal in mind or concentrate and pay attention to perform a task [15]. The lack of sleep and/or exercise, loneliness, or stress, often present in our daily lives, can also each impair these executive functions.

At the experimental level, it is feasible to evaluate the executive component through the so-called ANT or Attentional Network Test [16]. Originally, Fan, Posner and collaborators [16] developed a procedure that combined the flanker task [17] with the visual cueing paradigm [18], to allow testing the efficiency of three attentional networks (the orienting, the alerting and the executive control networks) proposed by Posner and Petersen [19,20]. The traditional version and subsequent modifications of this task have showed their independence, but also the cooperation between the three networks [21–23]. This procedure has been widely used to assess the components of visual attention in healthy adult [16,21,22], child population [24], and subclinical persons [25,26], but also in a diversity of studies including genetic studies [27] and neuroimaging [28], or meditation [29].

More recently, a version of the ANT task called ANT-I task (Attentional Network Test-Interactions) adapted by Callejas et al. [21], that combines the flanker task with the auditory (instead of visual) cueing paradigm, was applied to study the effect of acute aerobic exercise on cognitive functions. Namely, Huertas and his colleagues [30] found accelerated reaction times and a reduced alerting effect (compared with the rest condition) in a highly experienced cyclists group. However, this kind of exercise did not modulate the functioning of either the orienting or the executive control attentional networks [30]. In another recent study, Noguera and her collaborators assessed both the spatial memory and the functioning of the three attentional networks in a sample of men distributed according to their age (60–69 and 70–79 years old), and aerobic exercise practice (sedentary vs sportsmen). Overall, sportsmen outperformed sedentary participants in most of the measures employed, showing a better spatial orienting and a more effectively functioning of the three networks [31].

Therefore, there are some factors that could help to slow down or even reverse the negative effects of normal aging. Namely, the practice of physical activity has been reported to improve spatial memory and executive functions of adults and elders [31–34]. This is connected with the increases of both grey and white matter resulting in better cognitive abilities [35,36]. It is hypothesized that aerobic sports ultimately contribute to increase the cognitive reserve which is considered a neuroprotective factor from cognitive decline [37].

Just as running, swimming or walking are considered type of aerobic exercise, most forms of dance may be also considered an aerobic exercise, and as such could contribute to reduce the risk of cardiovascular disease, help weight control, or to modulate the stress and depressive symptoms [38]. Dancing also involves other skills like coordination with music, and retrieval of sequences of movements, reinforcing spatial perception and memory [39] as well as executive functions [40]. It was demonstrated that elders practicing dancing activities reported remarkable improvements in equilibrium and consistency of steps [41]. These authors also showed that dancing is more beneficial than repetitive physical exercises, thus activating brain plasticity mechanisms at a greater extent. Pronounced differences in brain volumes were also found after an exhaustive dancing training [42]. However, those studies were unable to find differences in spatial memory due to the use of less sensitive tasks. On the contrary, using the virtual reality paradigm, which consistently proved to be superior to traditional spatial measurements, may be able to succeed in this matter [11–13].

Thus, it would be interesting to explore whether the practice of another type of aerobic exercise, such as salsa dancing, could have some beneficial effects for cognitive health.

The aim of this study was to assess if dancing, that includes lots of jumping or turning, affects spatial memory and executive functions using more sensible virtual reality tasks like virtual reality-based tasks and ANT-I task for assessing spatial memory and executive functions, respectively. Given the beneficial effect that aerobic exercise has on our mental health, we hypothesized that dancers will show better performance than no-dancers.

2. Materials and Methods

2.1. Participants

A sample of 46 healthy adults participated in this study (aged 49–70 years). Twenty-six were dancers (14 men, 12 women) and twenty control participants (10 men, 10 women). Participants were recruited at dancing academies, old-adults university courses and social clubs in Almeria. An interview was made in order to obtain information about their sport habits, videogames practice, health condition and academic background (see Table 1). Those with any neurological disease, traumatic brain injury, cardiopathy, drug intake, or any other condition that could interfere with performance were excluded. To be classified as dancers, participants must have been practicing salsa dancing for at least six months prior to the study and did not practice any other kind of aerobic activity during the last year. In contrast, control participants had not practiced dancing or any sport for the same period of time. All participants were recruited from the province of Almeria. The study was approved by the University of Almeria Ethical Committee (UALBIO2015/012) and fulfills the requirements of the European Communities Council Directive 2001/20/EC and the Helsinki Declaration for biomedical research involving humans. Participants were informed in advance that they would be included in a study examining spatial memory and executive functions, though the hypotheses of the study were never revealed. They were also told that they were free to leave the experiment at any time.

Table 1. Characteristics of the sample (mean + SD).

	Dancers				Sedentary			
	Men		Women		Men		Women	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age	57.1	5.8	54.9	4.35	61	5.1	54.2	3.5
Educational Level 1–3	2	0.78	2.33	0.77	2	0.9	1.9	0.9
Years Dancing	9.1	7.9	7.4	7.8	-	-	-	-
Videogame Experience 1–4	1.35	0.6	1.58	0.9	1.1	0.3	1.7	1.1

2.2. Materials

The following neuropsychological tests were applied: (1) the Kaufman Brief Intelligence Test (K-BIT, [43]). (2) The FAS Word Fluency Test [44] to measure phonologic and semantic fluency. (3) The Zoo Map subtest of the BADS battery (Behavioral Assessment of Dysexecutive Syndrome, [45]) to assess planning ability.

In addition, we used an adapted version of the ANT-I task [21] to evaluate the ability of participants to prepare to response faster in the presence of a warning signal to orient their attention according to the information provide by a spatial cue (valid vs invalid), and to efficiently respond to a target flanked by distractors.

Finally, to assess spatial ability, the Boxes Room task was used, which consisted in a virtual room where participants had to find 3 rewarded boxes out of 16 possible rewarded positions in ten consecutive trials (see [8]). They used a joystick to move around the room. The task was administered on an HP 2300-MHZz notebook equipped with 6000 MB of RAM and a 15 inch XGA TFT color screen (1024 × 768).

2.3. Procedure

The evaluation took place in the Neurosciences laboratories at the University of Almeria. All participants were tested individually. Participants received verbal and written instructions before each test and they were administered in the following order: Interview, K-BIT, Zoo Map test, FAS, ANT-I task, and Boxes Room task. Assessment lasted between 1 h 30 and 2 h, taking a break after completion of each one.

Kaufman brief intelligence test. This test consists of two subtests. In the verbal subtest, participants observed a series of pictures and named the object represented on them. For the second part of this subtest, a definition, together with some letters of the name were given as cues, and participants had to say the name that the definition referred to. For the non-verbal part, participants had to find out the relationship in a set of meaningful (people or objects) and abstract stimuli (symbols) and point to the correct answer among all the ones given.

The FAS Word Fluency Test. In this test, participants were required to name as many words as possible in one minute starting with the letters F, A, and S, excluding proper nouns and diminutives (phonemic verbal fluency). For the categorical fluency part, they were asked to generate animal names (Animal Naming) as far as possible in one minute, having no restrictions during the stage.

The Zoo Map Test. Participants observed the map of a zoo and they were instructed to draw a line from the entrance (starting point) to the Cafeteria (finish point) with some limitations. Thus, it was mandatory to go through a number of locations before they reached the finish point. Besides, some roads could only be taken once, while others could be taken as many times as they wanted.

The ANT-I Task. Participants had to respond to the direction of a central arrow, as fast and as accurately as possible, by pressing the "C" key with the left hand if a leftward arrow was displayed, and the "M" key with the right hand if that rightward arrow appeared. Figure 1 illustrates the sequence of events presented in each trial. Firstly, a central plus sign was presented for 450–1450 ms. Secondly, a 2000 Hz alerting sound appeared in half of the trials for 400 ms. This warning signal only indicated that participants should be prepared to respond to the upcoming target. Thirdly, a spatial orienting cue (an asterisk) was presented for 50 ms above or below the plus sign on 2/3 of the trials, specifying information on where the target will appear. No cues appeared in the remaining trials. Finally, the target and flankers were presented either on the same or opposite locations of the previous orienting cue for 3000 ms or until participants' response. The fixation point was again presented for 1000 ms, before starting the next trial. The presence or absence of the alerting sound (tone) constituted the two levels of alerting condition. The orienting variable was defined by the presence of the spatial cue (valid trials, when the cue was presented at the same location as the target arrow; invalid trials, when the spatial cue appeared at the opposite location to the target), or the absence of the spatial cue (no-cue trials, when the cue was not presented). The conflict condition was made by means of flankers, consisting of four arrows identical to the target, surrounding the target either pointing in the same direction as the target (congruent condition), or pointing opposite direction (incongruent condition).

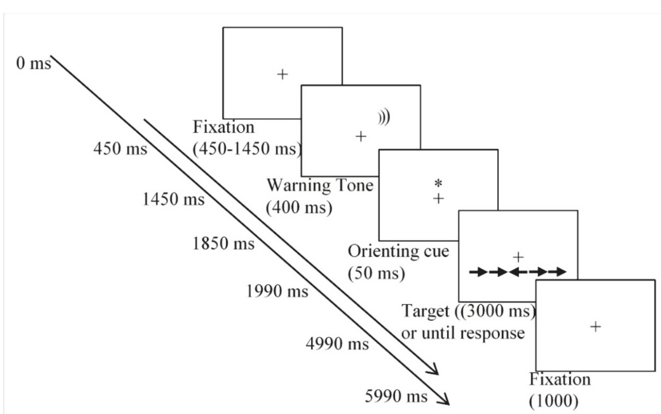

Figure 1. Example of procedure in the ANT-I (Attentional Network Test-Interactions). The timing of events is presented on the left.

Participants performed a practice block of 12 trials, followed by 4 experimental blocks of 48 trials each, 24 trials per each alerting (tone/no tone) and executive condition (congruent/incongruent), and 24 trials per orienting condition (16 trials with spatial cue and 8 trial with no cue. The trials were randomly ordered within each block.

The Boxes Room Task. This task, described in [8], consisted of a square virtual room with sixteen brown boxes, distributed in 4 rows with 4 boxes per row. The room also displayed different elements located on the walls to disambiguate the room, like a door, a window and several paintings. Three out of the sixteen boxes were rewarded, and participants were asked to open the boxes one by one in order to find them. To do this, they used a joystick to navigate through the environment. To open a box, they must be situated in front of it and press a button. If the box was rewarded, it changed its color from brown to green and a pleasant melody sounded. In contrast, if the box opened was incorrect, it turned to red color and an unpleasant melody sounded. They were instructed to open the lowest number of incorrect boxes while opening the rewarded ones, and to do this as fast as possible. The task was composed of ten trials. Rewarded boxes were located in the same position during the ten trials. Each trial ended when the participants opened all the rewarded boxes or after 150 s elapsed. Number of errors committed were registered.

2.4. Statistical Analysis

Kolmogorov–Smirnov test was used to estimate normality. When the normality assumption was not met, samples were compared with a Mann–Whitney U test for independent samples. Non-parametric tests were required for analyzing performance in the Zoo map task.

A two-way ANOVA (Group (Dancers vs. Control) × Gender) was applied to analyze the scores of K-BIT and FAS-A tasks. Errors in the Boxes Room Task were analyzed using an ANOVA (Group (Dancers vs. Control) × Gender × Trial) with repeated measures in the last variable. Fisher's Least Significant Differences (LSD) test was applied for post-hoc analyses.

Regarding ANT-I task, trials containing an incorrect response (1.3% of trials), or those with reaction times falling more than 2.5 standard deviations from the overall mean RT (1.7% of trials), were removed from analyses. Mean RTs and errors were analyzed employing a mixed design ANOVA with Group (Dancers vs Control) and Gender as the between-subjects factors, and Auditory Signal (Tone, No Tone), Spatial Cue (No Cue, Valid, Invalid), and Flanker Type (Congruent, Incongruent), as the within-subjects factors. The alerting effect was calculated as the difference between the trials with auditory signal trials and those without it. The orienting effect was obtained by calculating the difference between the valid and invalid trials. The conflict effect was calculated as the difference between the congruent and incongruent trials.

Finally, a Pearson correlation was estimated between Age and the set of variables used in this study. An ANCOVA was run to determine the effect on those statistically significant correlations. Differences were considered significant if $p < 0.05$. The statistical analyses were performed using STATISTICA, version 13 (TIBCO, Palo Alto, CA, USA) and IBM SPSS, version 25 (SPSS Inc., Chicago, IL, USA).

3. Results

Data fulfilled the assumption of normality in all the variables studied but Zoo test. In addition, a Pearson correlation showed a statistically significant negative correlation only between Age and naming tests (Fas-A and Animal Naming) (see results in point 3.3).

3.1. K-BIT (General Intelligence Measurement)

ANOVA showed that groups were very homogeneous. Neither the Gender factor ($F(1,43) = 0.455$ $p = 0.51$), Group ($F(1,43) = 0.042$ $p = 0.83$), nor the interaction Gender x Group ($F(1,43) = 0.58$ $p = 0.58$), produced statistically significant effects (see Figure 2).

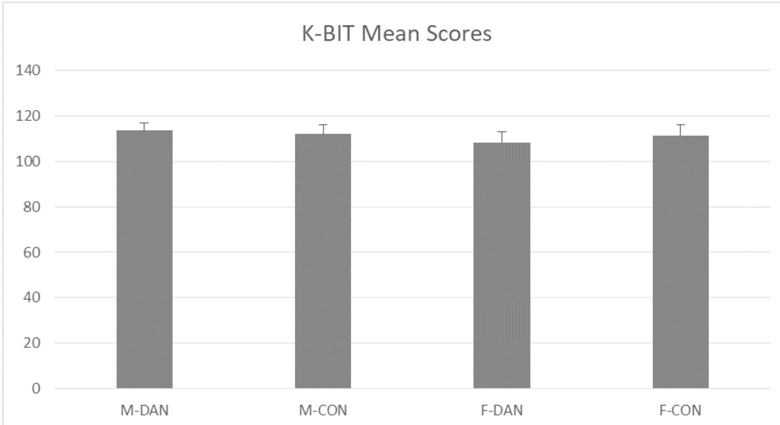

Figure 2. Kaufman Brief Intelligence Test (K-BIT) mean scores. Groups were very homogeneous in intelligence. No group differences emerged. Male dancing (M-DAN); female dancing (F-DAN); male control (M-CON); female control (F-CON). Mean + SEM.

3.2. Zoo Test

Mann–Whitney U test for independent samples disclosed significant differences between dancers (mean range 27.79) and controls (mean range 17.93) (U = 148.5, $p < 0.005$) (see Figure 3).

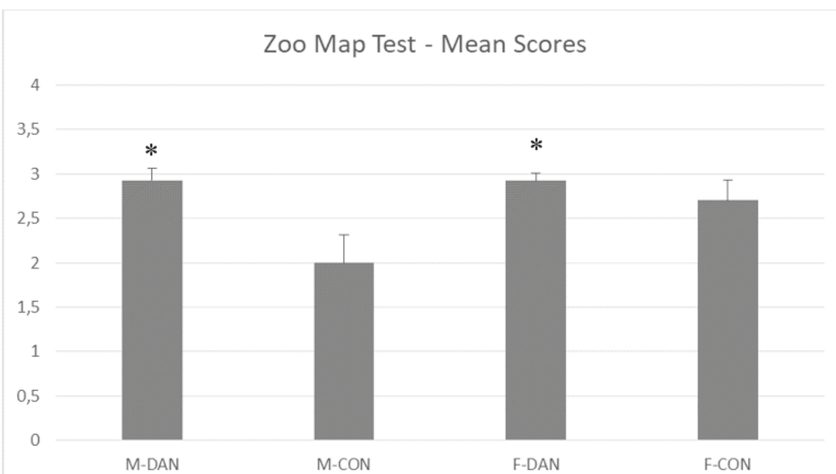

Figure 3. Zoo map test. Note that dancing groups outperformed controls. This indicates that they are more efficient in planning. Male dancing (M-DAN); female dancing (F-DAN); male control (M-CON); female control. Mean + SEM. * Significant differences with the control counterpart ($p < 0.005$).

3.3. FAS-A Test and Animal Naming

ANOVA applied to FAS-A test showed a significant main effect of Gender factor, $F(1,43) = 5.47$; $p = 0.020$), but no effect of Group factor, $F(1,43) = 3.33$; $p = 0.070$), or Gender x Group interaction, $F(1,43) = 2.09$; $p = 0.150$). Mean scores showed that women ($\overline{X} = 12.03$) outperformed men ($\overline{X} = 9.66$) in this task, although this was not linked with the practice of dancing (see Figure 4). In addition, a Pearson correlation showed a statistically significant negative correlation between Age and Fas-A (−0.455, $p <$

0.001) and Age and Animal Naming (−0.563, $p < 0.001$). ANCOVA confirmed the significant effect of Age on both test; Fas-A (t = −3.16, $p < 0.003$) and Animal Naming test (t = 4.29, $p < 0.001$).

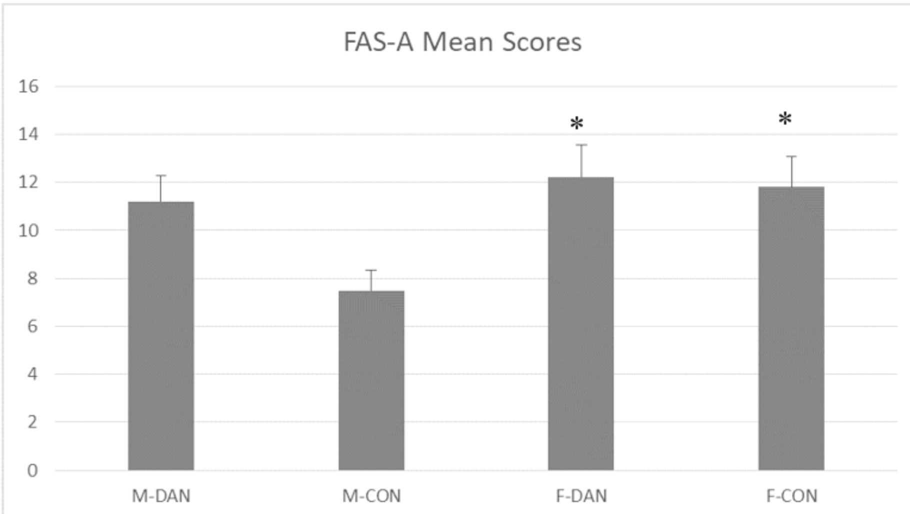

Figure 4. FAS Word Fluency Test mean scores. Women outperformed men in this task. This was independent of the practice of dancing. Male dancing (M-DAN); female dancing (F-DAN); male control (M-CON); female control (F-CON). Mean + SEM. * Significant differences with men ($p < 0.05$).

Scores of Animal Naming were also analyzed. ANOVA revealed that there were neither a significant main effect of Gender, $F(1,43) = 1.72$; $p = 0.190$), nor Group, $F(1,43) = 2.56$; $p = 0.110$), but a statistically significant interaction Gender x Group, $F(1,43) = 8.23$; $p = 0.006$). A post-hoc analysis (Fisher LSD Post-hoc test) showed that men in the dancing group ($\overline{X} = 21.85$) and women in the control group ($\overline{X}= 21.50$) scored better than men in the control group ($\overline{X} = 16.30$) (see Figure 5).

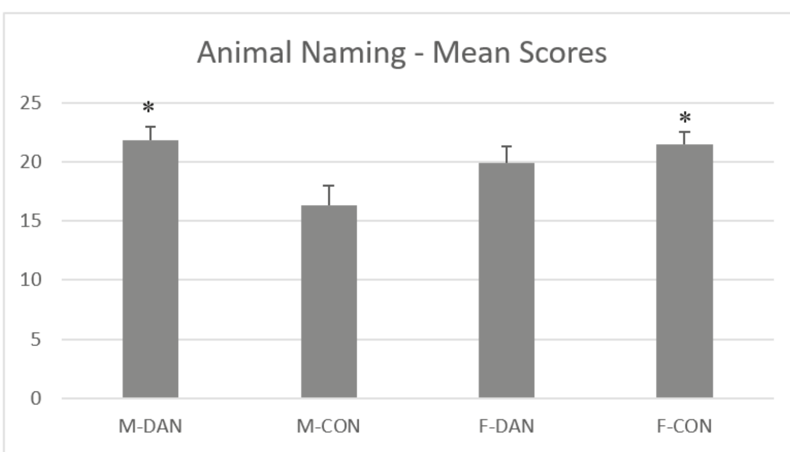

Figure 5. ANIMAL NAMING. Female controls and men in the dancing group scored better than men controls. Male dancing (M-DAN); female dancing (F-DAN); male control (M-CON); female control (F-CON). Mean + SEM. * Significant differences with men controls ($p < 0.05$).

3.4. The ANT-I Task

3.4.1. Latencies

Data from the analysis of variance (see Table 2) showed revealed a significant main effect of Group, F(1,42) = 4.07; p = 0.05; ηp2 = 0.08, because of dancers responded faster (664.86 ms) than sedentary group (717.30 ms). The Gender main effect was not significant, F(1,42) = 0.03; p = 0.96. However we observed a significant interaction between Group and Gender, F(1, 42) = 5.68; p = 0.02; ηp2 = 0.12, due to that men dancers were fasters (635 ms) than controls (749 ms), F(1,22) = 6.01; p = 0.023; ηp2 = 0.21, while no differences were found between the two groups of women (695 ms for dancers vs 686 ms for no dancers), F(1,20) = 0.24; p = 0.62. Men dancers also responded faster (635 ms) than women dancers (695 ms), F(1,24) = 7.75; p = 0.01; ηp2 = 0.24. However, the difference between the groups of no dancers (men = 749 ms; women = 686 ms) was not significant, F(1, 18) = 1.46; p = 0.24).

Table 2. Mean RT (in milliseconds), and standard deviations (in italics) for each experimental condition of alerting (no tone, tone), orienting (invalid, no cue, valid), and conflict (congruent, incongruent) in the modified ANT-I task.

	Congruent		**Incongruent**	
	Dancers	**Sedentary**	**Dancers**	**Sedentary**
No Tone				
Invalid	634	684	736	797
	21	*24*	*19*	*22*
No Cue	637	694	736	791
	19	*22*	*19*	*22*
Valid	610	649	702	761
	18	*21*	*19*	*21*
Tone				
Invalid	613	671	735	785
	18	*21*	*19*	*22*
No Cue	587	644	703	772
	18	*20*	*19*	*21*
Valid	576	622	682	738
	18	*21*	*20*	*22*

We also found main effects of Auditory Signal, F(1,42) = 81.69; p = 0.000; ηp2 = 0.66, due to faster responses in the tone (678.54 ms) than those in the non-tone trials (703.61 ms); Spatial Cue, F(2, 84) = 51.82; p = 0.000; ηp2 = 0.55 (invalid = 708.08 ms; valid = 668.71 ms; no cue = 696.44 ms); and Flanker Type, F(1,42) = 804.11; p = 0.000; ηp2 = 0.95 (Congruent = 636.08 ms; Incongruent: 746.08 ms). We observed an interaction between Auditory Signal and Spatial Cue factors, F(2,84) = 8.43; p = 0.000; ηp2 = 0.17, indicating a significant larger orienting effect in the tone (46 ms) than in the no-tone trials (33 ms), F(1,45) = 4.23; p = 0.040; ηp2 = 0.09. In addition, a significant Auditory Signal x Flanker Type interaction was observed, F(1,42) = 7.60; p = 0.008; ηp2 = 0.15, since the presence of a tone improved the response speed in both congruent (619.8 ms) and incongruent trials (737.2 ms), compared to that of trials without tone (congruent 652.3 ms vs. incongruent 754.9 ms), with a conflict effect of 117 ms in the tone condition, relative to that of 103 ms observed in the non-tone condition. A new ANOVA was applied in each group to disclose their patterns of performance in the task.

Dancing group. The analysis showed a significant main effect of Auditory Signal, F(1,25) = 45,04; p = 0.000; ηp2 = 0.640, due to lower latency in the tone condition (649.33 ms) than in the non-tone condition (675.84 ms). The alerting effect was of 26.61 ms. There were also a significant main effect of Spatial Cue, $F(2,50) = 32.63$; $p = 0.000$; $\eta p2 = 0.570$, since participants responded more quickly in the valid trials (642.44 ms) than in the invalid (679.45 ms) or no cue trial (665.72). The orienting effect was of 37.01 ms. The Flanker Type was also statistically significant, $F(1,25) = 482.30$; $p = 0.000$; $\eta p2 = 0.950$, because of faster responses in the congruent condition (609.42 ms), than in the incongruent condition (715.65 ms), being the conflict effect of 106.23 ms.

The Auditory Signal factor interacted with the Spatial Cue variable, $F(2,50) = 7.16$; $p = 0.002$; $\eta p2 = 0.220$, because the difference between orienting effect for the trials with tone (45 ms) and for the trials without it (29 ms) was significant, $F(1,25) = 4.41$; $p = 0.040$; $\eta p2 = 0.15$ (see Figure 6). Finally, we found a significant Auditory Signal x Flanker Type interaction, $F(1,25) = 10.25$; $p = 0.004$, $\eta p2 = 0.290$). Post hoc analysis showed that dancing group exhibited an alerting effect when flankers were congruent with the target; irrespective of that spatial cue was valid (34 ms; $F(1,25) = 29.99$; $p = 0.000$; $\eta p2 = 0.550$) or invalid (24 ms; $F(1,25) = 5.47$; $p = 0.020$; $\eta p2 = 0.180$). However, when flankers and target were incongruent, the tone was advantageous only if the spatial cue informed where the target would appear (20 ms; $F(1,25) = 5.71$; $p = 0.020$; $\eta p2 = 0.190$), but not when the spatial cue provided invalid spatial information, (1 ms; $F(1,25) = 0.002$; $p > 0.050$).

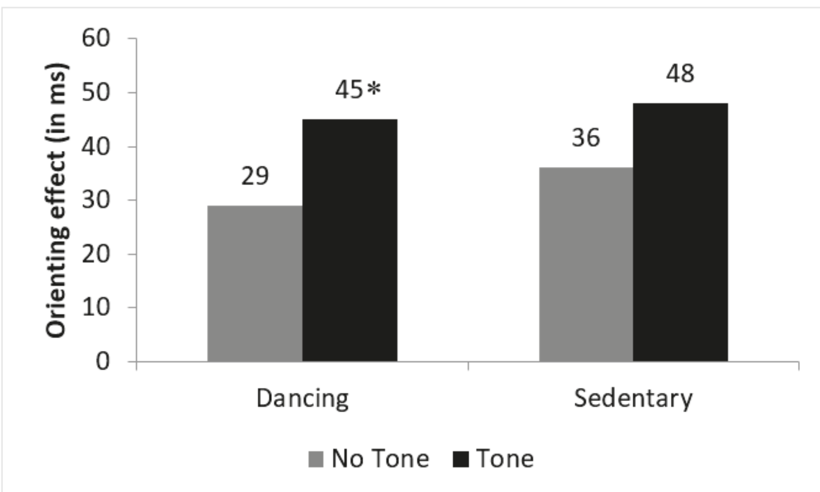

Figure 6. Average orienting effects (invalid RT minus valid RT) for trials with tone and non-tone (numbers over bars) in dancing and sedentary groups. The difference between both tone and non-tone trials was only significant for dancing group (* $p < 0.05$).

Sedentary group. The ANOVA revealed significant main effects of Auditory Signal, $F(1,19) = 36.12$; $p = 0.000$; $\eta p2 = 0.660$, with faster responses in the tone (705.21 ms) than in the non-tone trials (729.38 ms), (alerting effect of 24.17 ms); Spatial Cue, $F(2,38) = 21.68$; $p = 0.000$; $\eta p2 = 0.530$, showing the expected pattern (invalid 734.28 ms; valid 692.58 ms; no cue 725.02 ms), (orienting effect of 42 ms); and Flanker Type, $F(1,19) = 327.40$; $p = 0.000$; $\eta p2 = 0.950$, with a conflict effect of 113 ms (incongruent 774.01 vs congruent 660.58 ms). No interactions were observed ($p > 0.050$).

3.4.2. Errors

There were no significant main effects of Auditory Signal, Spatial Cue, Flanker Type, Gender or Group (all ps > 0.050). The Group and Gender factors interacted with the Alerting Network (Auditory Signal), $F(1,42) = 7.03$; $p = 0.01$; $\eta p2 = 0.14$, because only women dancers made a lower percentage of error in the presence of a warning signal (3.0 %), compared to that shown in the absence of it (3.7%), $F(1,11) = 4.48$; $p = 0.05$; $\eta p2 = 0.29$. This alert effect was not observed in the other groups.

The Flanker Type x Spatial Cue x Group interaction was also significant, $F(2,84) = 3.59$; $p = 0.030$; $\eta p2 = 0.08$. However, this interaction was due to the inclusion of non-cue trials. Dancing group showed a percentage of error of 3% in the incongruent trials, irrespective of the spatial cue type (invalid, valid, no cue), while sedentary group exhibited a percentage of error of 2% (invalid), 1% (valid), and 3% (no cue) incongruent trials. When target and flankers were congruent, dancers made less than 1% of errors (in the invalid and no cue conditions) or none in the valid condition. Likewise, control group also made few errors (1%) in the three orienting conditions. It is worthy to note that the average percentage of error (2%) committed for both dancing and sedentary groups was very low, and no significant differences emerged between them ($p > 0.050$).

3.5. The Boxes Room Task

Errors

ANOVA showed that there was not a significant main effect of Gender, $F(1,43) = 0.12$; $p = 0.720$, or Group, $F(1,43) = 0.02$; $p = 0.870$. Nevertheless, analyses disclosed a significant main effect of Trial factor, $F(8,344) = 17.44$; $p = 0.000$, and a significant interaction factor Gender x Group x Trial, $F(8,344) = 2.50$; $p = 0.011$. No significant effects were found in the interactions Gender x Trial, $F(8,344) = 0.82$; $p = 0.570$ or Group x Trial, $F(8,344) = 0.73$; $p = 0.650$. Post-hoc analyses showed that both groups (dancers and sedentary subjects) and both genders reduced their number of errors during the task, reaching the asymptotic level of performance on trial 5, but there were no differences when comparing their intergroup performance in gender and/or group (see Figure 7).

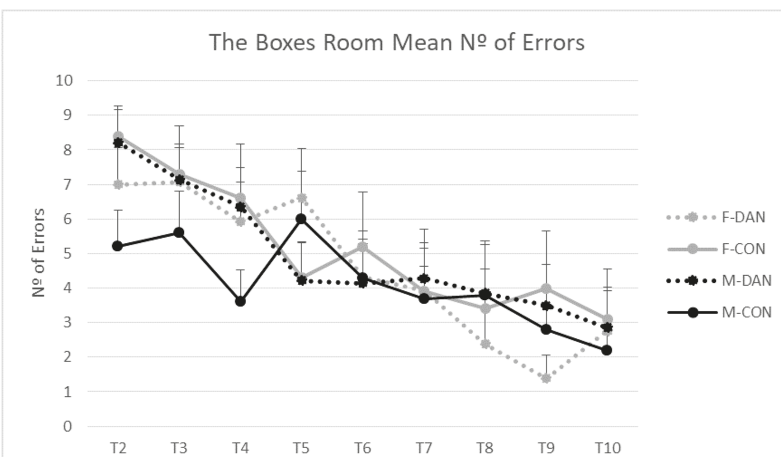

Figure 7. Number of errors in the spatial memory task. All groups improved across trials. Groups did not differ in the number of mistakes in the task. Male dancing (M-DAN); female dancing (F-DAN); male control (M-CON); female control (F-CON). Mean + SEM.

4. Discussion

The aim of this study was to explore the effect of dancing salsa, as an aerobic exercise, on spatial memory by using a virtual reality task, and on executive functions through the ANT-I task, in men and women. Subjects who had been practicing dancing were doing it for at least 6 months, including this activity in their normal routine. On the contrary, the control group had a sedentary lifestyle and had not practiced other sports in the last 6 months.

Regarding the scores in the neuropsychological tests, the K-BIT reported no differences in terms of intelligence between both groups, meaning that ageing-related decline was not affecting their performance. This is important because proves that the basal level was similar. Nevertheless, dancers outperformed controls in the Zoo Map test, a task involving planning ability. These results are consistent with previous studies in which dance improved executive functions [40]. Dancers are meant to have a trained observation capacity with the intention of imitating other's moves and actions. Thus, the dorsolateral prefrontal cortex and the pre-supplementary motor area are two brain regions involved in this activity [46] as well as in the planning and generation of actions [47]. Furthermore, this better performance could be mediated by structural and functional changes in the prefrontal cortex associated to aerobic fitness. Note that practice of aerobic activities was also related to better executive functions [31,48]. Thus, a greater gray matter volume was reported in prefrontal regions [49] as well as a higher activation in prefrontal regions such as the anterior cingulate [50,51].

In the FAS test, women's outperformed men, regardless of the group. This is not surprising if we consider that women traditionally score higher in verbal tests [52,53]. Either way, it is also important to highlight that these differences in the phonemic verbal fluency scores were milder between dancers (12.23 for women vs. 11.80 for men) in comparison with controls (11.21 for women vs. 7.5 for men). A possible explanation could be the compensation effect of dance practice. In addition, it is interesting to note that in the Animal Naming subtest, men included in the dancers group outperformed men in the control group, scoring at the same level as control women. Therefore, beyond the typical superiority of women in verbal tasks, dance practice seems to be a modulating factor that could improve performance. Thus a beneficial effect of dance was reported in a series of verbal tasks, which included the Alternative Uses test, considered together with the FAS test as a spontaneous flexibility measure [54]. Such tests disclosed differences in performance when comparing professional with novice dancers and they attributed these results to the degree of creativity of their professional dancers. It is worth noting that Age affect FAS and Animal Naming tests, as disclosed by Pearson correlations and ANCOVA test. Taking into account that men in the control group were slightly older, it is possible that these differences in verbal fluency could also be depended on age as well as in the above mentioned factors.

Regarding the ANT-I task, it should be noted that the present study follows the attentional model proposed by Posner and Petersen [19], which considerate that different attentional manifestations are produced by three attentional subsystems called the alerting network, the orienting network, and the executive control network. The three subsystems are functionally and anatomically independent neural networks, although work in cooperation to adapt information processing to the demands of the environment [30]. The alerting network provides the general activation of cortical and thalamic areas that prepare us for faster responding to any stimulus. The use of a warning signal (e.g., a tone) can induce a brain state related to alerting that differs from that activity produced by a target. The presence of a warning signal would induce a phasic extrinsic alertness related to the nonspecific activation that prepares us to response. This type of alertness is different from the so-called tonic intrinsic alertness or vigilance state, which implies sustained activation over a relatively long period of time, and varies according to the circadian rhythm (see [55], for a review about this network). The orienting network is a subsystem that allows shifting our attention around to various spatial locations in a voluntary or endogenous way, guided by our expectations of relevant locations or object features, or in an involuntary or exogenous manner as when is captured by the salient features of stimuli (e.g., an abrupt onset stimulus, form, color) (see [56], for a review). The ANT-I task used in the present study, containing trials with invalid orienting cues, allowed examining the cost of redirecting attention towards the target's location, relative to the advantage observed when the target appears in the same location that the spatial cue (valid trial). Finally, the executive control network plays an important role for monitoring and conflict resolution, error detection, or habitual response inhibition [20]. The trials with incongruent flankers generate a situation of conflict (with the target) that participants must resolve before responding.

To the best of our knowledge, no studies explored whether salsa dancing modulates performance on this ANT-I task. Most of research has focused on studying the influence of the chronic and acute aerobic sport practice (e.g., cycling, swimming, tennis) on attentional performance. Usually, findings suggest that regular aerobic exercise produce positive effects for executive functioning in healthy young and older people (see [57], for a review). We also found the typical effects of alerting, orienting and conflict in both dancing and sedentary groups. However, dancers responded faster than non-dancers presumably due to the effect of aerobic dancing. It is interesting to note that this improvement in the speed of response is mainly due to the men who practice dance, since the women of both groups showed a similar performance pattern. Somehow, this kind of aerobic exercise seems to benefit men more than women in terms of response latency. However, hearing a tone (which would induce the start-up of the alert network) seems to positively influence the performance of the women dancers in terms of accuracy, although this was lower than that observed in the men dancers.

Also, we obtained an interesting interaction between alerting and executive networks, with a larger conflict effect in the presence of a warning signal. We had already observed this interaction using the ANT-I task in a previous study in older sportsmen [31]. According to Posner and Rothbart [58], it seems that paying attention to the tone generate a "clearing of consciousness" effect (i.e., a subjective effect of emptying thoughts) that allow us preparing to response. Thus, the alerting network would modulate (inhibiting) the executive network. Finally, the alerting network also interacted with the orienting one. The orienting effect was larger for the tone trials than non-tone trials, but only in the dancing group. The alerting network seems to act on the orienting network in a similar way as it does on the executive network in this group. Taken together, the data seem to suggest that the dancing increases the general state of alert to respond faster (especially in men dancers) or to respond more accurately (particularly in women dancers) to any stimulus that appear in the visual field.

On the other hand, the Boxes Room Task has proven to be an effective test to assess spatial ability over traditional neuropsychological test [59]. This task usually discloses a gender dimorphism effect [60,61]. This was not the case in our study which reported that both men and women delivered a similar performance. Nevertheless, these results agree with another study which used the same paradigm with similar age groups, thus reporting no gender differences in the middle age group 45–54, and older adults 55–64 [62]. This could be due to the fact that the level of difficulty in this task was not adjusted correctly. Hence, when the task is too easy the dimorphic effect does not appear. Accordingly, it is necessary to find an optimal level of difficulty [8]. Our results also confirm recent findings reporting that women are as accurate as men [63] provided that both groups are given a sufficient amount of time to learn spatial relationships and repetitions. Therefore, the degree of familiarity with the environment would play a role as a modulating factor, making up for men's advantage. Another aspect to consider is the heterogeneity of the sample. The ages ranged from 49 to 70 years old, a quite high variability that might have added important inter-individual differences in our sample.

In addition, it is well known that the hippocampus plays an important role when performing the Boxes Room task [64]. It has been demonstrated that physical activity enhances the functioning of the hippocampus and other brain structures involved in spatial orientation. Thus, some studies suggest that physical activity is associated with a larger volume of the hippocampus [65] and hippocampal integrity [66], and consequently an aged-related loss of the hippocampal volume due to age can be compensated through the practice of aerobic sports [36].

Furthermore, the construct of cognitive reserve has been commonly related to healthy ageing, and its assessment includes different educational and recreational brain-stimulating activities across the lifetime [67]. A larger cognitive reserve is associated with a delaying in the onset of dementia and normal cognitive impairments in elderly [68]. Considering this, a better cognitive functions would be expected for subjects included in the dancer group in comparison with those in the control group, since dancing, as a physical exercise, is included among the factors that contribute to cognitive reserve [69]. However, sample heterogeneity, as mentioned before, might impede clearer differences since this neuroprotective effect of cognitive reserve would be more evident in aged participants, 60–70 years old, when cognitive decline becomes more pronounced [31].

Regarding the time needed for these changes in the brain to manifest, all the participants who took part in this study had been dancing regularly for a minimum of 6 months. However, in most of them this period was way longer, 8 years on average. Previous studies demonstrated that this period is enough for the benefits of sport practice to have an effect in the brain. In a study carried out by Erickson et al. [36] the hippocampus increased its volume after a 6-month exercise intervention. Maass, Duzzel, Goerke, Becke, Sobieray, and Neumann et al. [70] also reported an evident beneficial effect of aerobic exercise even after shorter interventions (3 months), since participants experienced a hippocampal volume increase and substantial memory improvements. Other studies obtained similar results in patients with depression [71] and schizophrenia [72] after a 3-month intervention. In addition, procedural and motor learning, such as dancing, entails a plastic reorganization of the human brain through functional and structural changes. Interestingly, our brain changes not only when we perform motor sequences, but also when we imagine practicing these exercises [73,74]. It would be interesting to determine the effect of dancing programs through virtual environments or mental practice in individuals with motor difficulties.

Finally, the interpretation of our results should take into account the following limitations. Thus, ours is a quasi-experimental study and participants were not randomly assigned to the groups. It is also important to note that other healthy habits that could be influencing cognitive functioning (e.g., diet, sleep routine) were not considered, and therefore it is impossible to determine to what extend they could influence on these results. Another important limitation is the sample's heterogeneity, since the age range was quite large. Increasing the sample and clustering participants by ages could solve this problem. Nevertheless, the number of participants is similar to previous studies using virtual reality-based tasks [75]. Thus, 10–15 participants per group seems to be a correct number to achieve valid conclusions. In our case, previous experiments with similar tasks provided replicable data [8,61]. Also dancing involves many different activities, including social contact, learning rhythms, and motor coordination which could be reflected on tests scores. It is difficult to separate the weight of each variable. More important, the general fitness level was not assessed and it is impossible to determine how this variable contributes to performance. Measures like VO2max could be included in further studies.

5. Conclusions

This study represents a first approach to determine the cognitive effects of dancing. The results proved that dancing have a beneficial effect in executive and more limited on spatial memory functions. This study suggests that cognitive stimulation therapies based on dancing could help to maintain or even improve cognitive skills, reducing age-related decline. Future research on this topic should consider an experimental design with bigger samples including not only healthy people but also persons with mild cognitive impairment.

Author Contributions: Conceptualization, C.N., R.F. and J.M.C.; methodology, C.N., D.C., A.R. and J.M.C.; investigation, D.C. and A.R.; resources, D.C., A.R., and R.F.; writing—original draft preparation, C.N., D.C., A.R., R.F. and J.M.C.; writing—review and editing, C.N. and J.M.C.; supervision, C.N., R.F. and J.M.C.; project administration, C.N. and J.M.C.; funding acquisition, J.M.C. All authors have read and agreed to the published version of the manuscript.

Funding: This investigation was supported by MINECO (PSI2015-67442-P).

Acknowledgments: We would like to thank José Ramón Ibañez for his help with English.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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International Journal of
Environmental Research and Public Health

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Article

Examining Body Satisfaction and Emotional–Social Intelligence among School Children: Educational Implications

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Received: 28 December 2019; Accepted: 18 March 2020; Published: 23 March 2020

Abstract: In childhood, the perception of body image is in the construction phase and emerges linked to the aesthetic ideals of society, which is well differentiated according to gender. In this way, according to people's interpretations of the environment and how to manage it emotionally, greater or lesser body satisfaction may be generated, which could have irreversible consequences for children. Therefore, our interest lies in how body image satisfaction and gender can act as modulating variables of emotional intelligence in childhood, analyzing differences in the intrapersonal, interpersonal, stress management, adaptability, and mood dimensions of emotional intelligence, according to the degree of body image satisfaction and the child's gender. A total of 944 Primary Education students selected by multistage cluster sampling, 548 boys and 396 girls aged between 9 and 12 years from different schools in Extremadura (Spain), participated in the research. The study design was descriptive, and questionnaires to measure emotional intelligence, self-perception, and body image satisfaction were used. An analysis of descriptive statistics, a Chi-square test to measure the variance/invariance of the participants' distribution according to their satisfaction with body image and gender, and a MANOVA to determine the possible effects of satisfaction with body image as well as of gender on emotional intelligence were conducted. Regardless of gender, children who were satisfied with their body image showed higher interpersonal intelligence, greater adaptability, and better mood. With respect to gender, girls showed higher stress management than boys. Throughout Compulsory Education, it is necessary to promote campaigns imparted by specialists to prevent body image dissatisfaction, so that the benefits can reach the entire educational community (students, teachers, and parents). In this work, several possibilities are described to meet the demands of contemporary society.

Keywords: body image; emotional intelligence; children; education

1. Introduction

The term emotional intelligence was introduced by Salovey and Mayer [1] referring to the ability to understand and manage emotions to channel them in a positive way so that they work for us and not against. There are three main models of emotional intelligence: skill model or four branches of Mayer and Salovey [2], Goleman's emotional competencies model [3,4] and Bar-On's emotional and social intelligence model [5].

The Bar-On [5] emotional and social intelligence model is defined as an array of interrelated emotional and social competencies, skills and behaviors that determine how well we understand and express ourselves, understand others and relate with them, and cope with daily demands, challenges and pressures [6].

These competencies and skills have been grouped into five dimensions or factors for further study: 1) intrapersonal (the ability to understand our emotions and communicate them to others), 2) interpersonal (the ability to understand and appraise the emotions of others), 3) stress management (the ability to manage and control our emotions), 4) adaptability (flexibility and efficacy to resolve conflicts), and 5) mood (the ability to maintain a positive attitude in life) [3]. Based on these dimensions, a social-affective profile, based on a person's emotional and social skills, which help them to operate in society daily, can be created [1,4].

Focusing on the stage of childhood as the object of this study, emotional intelligence takes on an essential role, because children's nervous system, psyche, and personality are still in formation and construction [5–8]. Hence, many of the feelings, emotions, and perceptions that arise at this stage can become consolidated as beliefs, contributing to generate a series of consequences that may emerge during later stages and that can condition people's personality and their lifestyle [9–11].

In this regard, one of the variables that is receiving increasing attention in developmental stages like childhood and adolescence is body image [12–14], as it is being formed according to the individual's subjective ratings of his or her own body, and to the social appraisals received from others [15]. In this sense, the way people perceive, feel, and behave in relation to their own body may be associated with high body satisfaction or body dissatisfaction. If not properly controlled or directed, this can cause serious consequences, such as the development of eating behavior disorders [16,17].

In this line, the scientific literature has highlighted the link between body satisfaction/dissatisfaction and emotional intelligence, based on the fact that cognitive processes are directly affected by the management of emotions [18,19]. In fact, people's adaptive and accurate beliefs or perceptions are often associated with adequate management of emotions and, therefore, greater emotional intelligence, contrary to what is observed in maladaptive and inaccurate beliefs [20].

However, body satisfaction is determined by the aesthetic ideal prevailing in society, which currently focuses on the cult of the body, youth, and beauty as a goal in order to achieve social success [21]. Therefore, when we speak in terms of the canons of beauty in society, it is imperative to differentiate according to gender, as aesthetic ideals differ in men and women. In our Western society, men seek a body image where their muscles predominate, whereas women pursue thinness [22,23].

Thus, taking into account the role of body satisfaction/dissatisfaction and gender in emotional intelligence, the main objective of this work is to provide information and/or deepen our knowledge about the modulating variables of emotional intelligence in childhood. For this purpose, we intend to analyze the differences in the dimensions of emotional intelligence depending on children's degree of satisfaction with their body image and their gender. These factors and their joint study are taken into consideration, given the interest and relevance of the study of body image at these ages, with gender being a possible determinant in relation to emotional intelligence and body satisfaction.

The main aim of this study is to know how body image satisfaction and gender can act as modulating variables of emotional intelligence in childhood, analyzing differences in the intrapersonal, interpersonal, stress management, adaptability, and mood dimensions of emotional intelligence, according to the degree of body image satisfaction and children's gender. Based on this aim, the hypothesis proposed is that participants who show greater satisfaction with their body image will have higher levels of emotional intelligence.

2. Materials and Methods

2.1. Participants

Participants in the investigation were 944 students from 5th and 6th grade of Primary Education, 548 boys (58%) and 396 girls (42%), aged between 9 and 12 years (M = 10.76, SD = 1.11). The participants were from eight schools of the Autonomous Community of Extremadura (Spain). Sample selection was done by multistage cluster sampling, randomly selecting the groups in the schools that had various subgroups in the above-mentioned grades of Primary Education.

2.2. *Instruments*

2.2.1. Emotional Intelligence

To measure children's emotional intelligence in the primary education stage, we used the Emotional Quotient Inventory: Young Version (EQ-i: YV), designed by Bar-On and Parker [4] and validated in Spanish by Ferrándiz, Hernández, Bermejo, Ferrando and Sáinz [3]. This instrument consists of 60 items that make up the global factor Emotional Intelligence, divided, in turn, into five dimensions: Intrapersonal (6 items: emotional self-awareness, assertiveness, personal respect, self-actualization, independence), Interpersonal (12 items: interpersonal relationships, social responsibility, empathy), Stress Management (12 items: stress tolerance, impulse control), Adaptability (10 items: problem solving, reality appraisal, flexibility), and General Mood (14 items: joy, optimism). To these 60 items were added another 6 items that make up a Positive Impression Scaleto measure, the degree to which subjects respond randomly or distort their responses as a function of social desirability. The answers to the questionnaire were rated on a four-point Likert scale ranging from 1 (never happens to me) to 4 (always happens to me).

The EQ-i: YV presented a structural model with good adjustment rates (χ^2 = 24,780, df = 5, $p < 0.001$; NFI = 0.966; CFI = 0.973; IFI = 0.973; RMSEA = 0.069) and had adequate internal consistency for the total number of items that constitute the global Emotional Intelligence factor, with a Cronbach alpha coefficient of 0.84. The Cronbach alpha indexes (α = 0.84) and composite reliability (CR = 0.80) indicate an adequate overall reliability of the EQ-i: YV with an average variance extracted (AVE) of 0.50. Likewise, the dimensions or factors of the questionnaire present an acceptable reliability and AVE ≥ 0.50 [Intrapersonal (α = 0.67, CR = 0.82, AVE = 0.50); Interpersonal (α = 0.70, CR = 0.90, AVE = 0.56); Stress management (α = 0.69, CR = 0.87, AVE = 0.56); Adaptability (α = 0.73, CR = 0.88, AVE = 0.54); and Mood (α = 0.72, CR = 0.91, AVE = 0.57)]. Lastly, it should be noted that Items: 6, 15, 21, 26, 28, 33, 37, 46, 49, 53, 54, and 58 were worded negatively, so their scores were reversed to facilitate the process of data analysis.

Then, the invariance of the EQ-i: YV was examined according to gender and the degree of conformity with the figure. The values found in the indexes for the Unconstrained Models, with differences less than 0.01 of the CFI indices between the four models, indicate that the factorial loads of the questionnaire are equivalent in both cases (Table 1).

Table 1. Multigroup analysis of invariance by gender and degree of conformity with the figure.

Groups	Models	$\chi2$	df	$\chi2$/df	$\Delta\chi2$	p	Δdf	CFI	TLI	RMSEA
Gender	Unconstrained	38.319	10	3.812	-		-	0.962	0.925	0.058
	Measurement weights	43.906	14	3.136	5.588	0.232	4	0.960	0.943	0.051
	Structural covariances	44.732	15	2.982	6.413	0.268	5	0.960	0.947	0.049
	Saturated model	58.284	20	2.914	19.965	0.030	10	0.949	0.949	0.048
Body Image Satisfaction	Unconstrained	58.829	15	3.922	-		-	0.940	0.920	0.059
	Measurement weights	93.090	23	4.047	34.261	<0.001	8	0.904	0.916	0.061
	Structural covariances	95.775	25	3.831	36.946	<0.001	10	0.903	0.918	0.059
	Saturated model	132.686	35	3.791	75.857	<0.001	20	0.902	0.910	0.058

2.2.2. Self-Perception of Body Image

To evaluate the children's own body image and the ideal body image, we used the Stunkard Figure Rating Scale [24]. This scale consists of 9 figures that progressively increase in size, going from very thin (value 1) to very obese (value 9). The own body image is the number of the figure selected by the participants in response to the heading "choose the figure that reflects how you think you look". The ideal body image is the number of the figure chosen in response to the header "choose your ideal figure". The scale has adequate validity and test-retest reliability [25]. In previous recent studies in the Spanish context and with samples of the same age as our research, the instrument was valid and reliable [26]. To be able to define one's own body image and the ideal body image, following other authors, four categories were created to group the participants: Low body weight (values 1 and 2), normal weight (values 3 and 4), overweight (values 5, 6, and 7), and obesity (values 8 and 9).

2.2.3. Satisfaction with Body Image

This variable is defined as the difference between one's own perceived body image and the perceived ideal body image [27]. Based on this, a score of satisfaction with body image was created for each participant by subtracting the number of the figure indicated as the ideal perceived body image from the number of the figure selected as one's own perceived body image. To facilitate the grouping of the participants and the subsequent analyses, three categories of body image satisfaction were created: satisfied (own image = ideal), dissatisfied (own − ideal = ± 1), very dissatisfied (own − ideal ≥ ± 2).

2.3. Procedure

This study was approved by the Bioethics and Biosafety Committee of the University of Extremadura (N. 0063/2018). All participants were treated in agreement with the ethical guidelines of the American Psychological Association with respect to consent, confidentiality, and anonymity of answer.

We followed a protocol to ensure that data collection was carried out in a similar manner throughout the process. First, we contacted each of the schools and requested a meeting with the director for any questions about aims, goals, time, and grades that could be involved in the research. After they accepted the proposal, the director set up a meeting with the teachers, and we proposed a suitable schedule for the administration of the tests. In addition, all participants received an informed consent form to be signed by their parents or legal guardians, authorizing their participation in this research, as they were aged between 9 and 12 years.

Prior to the collective administration of the questionnaires during the agreed schedules, the main investigator briefly explained the procedure, as well as the instructions to complete the questionnaires, informing the participants that the data they provided would be anonymous and confidential. The duration was approximately 30 to 40 minutes for each class, and the main investigator was present at all times to clarify any doubts that could arise during the process.

At the end of data collection in each class, a brief informal interview was held with the teachers to discuss some aspects or extraneous variables to be taken into account in some students. Likewise, after completing the process in each school, we met the directors to thank them and discuss the process, ensuring the availability of the research data at any time.

2.4. Data Analysis

The factorial structure of the EQ-I: YV was evaluated using the Cronbach alpha coefficient, the CR, and the AVE. The Chi-square test establishes the variance/invariance of the participants' distribution according to their satisfaction with body image and gender. The data was submitted to the Kolmogorov–Smirnov test to analyze the assumption of normality, the Rachas test to contrast the assumption of randomization, and the Levene test to contrast the assumption of homocedasticity. We found that $p > 0.05$ in all contrasts, so the use of parametric tests was justified. In order to determine the possible effects of satisfaction with body image as well as of gender on emotional intelligence, a multivariate analysis of variance (MANOVA) was conducted, in which the dependent variables corresponded to the five dimensions of Emotional Intelligence, and the independent variables were children's satisfaction with body image and gender. The assumptions of normality, randomization, and homoscedasticity were contrasted with the Kolmogorov–Smirnov, Rachas, and Levene tests, respectively.

3. Results

Table 2 presents the distribution of the participants according to their body image satisfaction and gender.

Table 2. Distribution of Participants according to Body Image Satisfaction and Gender.

Body Image Satisfaction	Female		Male		Total	
	n	%	*n*	%	*n*	%
Satisfied	104	26.3	120	21.9	224	23.7
Dissatisfied	214	54	324	59.1	538	57
Very dissatisfied	78	19.7	104	19	182	19.3
Total	386	100	534	100	944	100

As for body image satisfaction, it should be noted that 76.3% of the participants were not satisfied with their body image, specifically 55% preferred to be thinner and 20% preferred to be heavier/more athletic. In relation to gender, the distribution of the groups' satisfaction with body image was equivalent ($\chi2(2) = 2.237$, $p = 0.327$). However, there were differences ($\chi2(2) = 8.471$, $p = 0.014$) in relation to the feeling of dissatisfaction because, although the percentage of girls (56%) and boys (54.3%) who preferred to have a thinner build was equivalent ($p > 0.05$), the percentage of boys (23.2%) who preferred to have a more athletic build was higher ($p \leq 0.05$) than that of the girls (15%).

Table 3 shows the means and standard deviations obtained for Emotional Intelligence as a function of the groups' satisfaction with body image and gender.

To analyze the effect of body image satisfaction and gender on emotional intelligence, a MANOVA was carried out, including as independent variables body image satisfaction (satisfied, dissatisfied, and very dissatisfied) and gender (female and male) and, as dependent variables, all the dimensions of emotional intelligence (intrapersonal, interpersonal, stress management, adaptability, and mood).

The MANOVA found significant main multivariate effects of body image satisfaction (Wilks $\lambda = 0.881$, $F(10, 1640) = 10.678$, $p < 0.001$, $\eta = 0.061$), gender (Wilks $\lambda = 0.968$, $F(5, 820) = 5.503$, $p < 0.001$, $\eta = 0.032$), and their interaction (Wilks $\lambda = 0.978$, $F(10, 1640) = 1.869$, $p = 0.045$, $\eta = 0.011$).

In contrast, the univariate comparisons showed the existence of a significant main effect of the degree of body image satisfaction in the emotional intelligence interpersonal components, $F(2, 834) = 9.026$, $p < 0.001$, $\eta = 0.021$, stress management, $F(2, 834) = 3.348$, $p = 0.036$, $\eta = 0.008$, adaptability, $F(2, 834) = 9.612$, $p < 0.001$, $\eta = 0.023$, and mood, $F(2, 834) = 51.23$, $p < 0.001$, $\eta = 0.111$, with no significant main effect in the intrapersonal component, $F(2, 834) = 2.863$, $p = 0.058$, $\eta = 0.007$.

With regard to gender, there was a significant main effect in the emotional intelligence interpersonal components, $F(1, 834) = 6.257$, $p = 0.013$, $\eta = 0.008$, and stress management, $F(1, 834) = 7.419$, $p = 0.007$, $\eta = 0.009$, with no significant main effect in the intrapersonal components, $F(1, 834) = 2.977$, $p = 0.085$, $\eta = 0.004$, adaptability, $F(1, 834) = 3.267$, $\text{p} = 0.071$, $\eta = 0.004$, or mood, $F(1, 834) = 0.778$, $p = 0.378$, $\eta = 0.001$. In addition, a significant interaction was found between body image satisfaction and gender in the stress management component, $F(2\ 834) = 3.636$, $p = 0.027$, $\eta = 0.009$.

Table 3. Means and Standard Deviation of Emotional Intelligence Dimensions according to Body Image Satisfaction and Gender.

EI Dimensions		Female		Male		Total	
		M	*SD*	*M*	*SD*	*M*	*SD*
Intrapersonal	Satisfied	14.92	2.71	14.92	3.50	14.92	3.16
	Dissatisfied	14.56	3.58	14.02	3.35	14.24	3.45
	Very dissatisfied	14.85	3.60	13.70	2.79	14.11	3.13
	Total	14.69	3.33	14.22	3.36	14.41	3.36
Interpersonal	Satisfied	42.76	5.50	42.60	5.02	42.67	5.23
	Dissatisfied	41.91	5.06	40.09	5.19	40.81	5.21
	Very dissatisfied	41.46	2.02	39.61	7.37	40.28	6.06
	Total	42.14	5.04	40.67	5.49	41.27	5.36
Stress management	Satisfied	33.45	5.43	32.81	6.99	33.10	6.33
	Dissatisfied	32.95	5.29	31.49	5.55	32.47	5.44
	Very dissatisfied	33.08	5.68	28.63	5.21	30.56	5.67
	Total	33.14	5.36	32.26	5.99	32.48	5.75
Adaptability	Satisfied	28.86	4.54	30.60	5.15	29.81	4.95
	Dissatisfied	27.98	4.73	28.78	4.86	28.46	4.82
	Very dissatisfied	27.15	4.27	27.17	4.76	27.17	4.56
	Total	28.18	4.65	29.09	5.01	28.72	4.89
Mood	Satisfied	49.25	5.50	50.50	3.71	49.94	4.63
	Dissatisfied	47.05	5.65	46.43	5.77	46.68	5.73
	Very dissatisfied	42.31	5.10	43.09	6.32	42.81	5.89
	Total	47.35	5.82	47.15	5.80	47.23	5.80

Note: EI (Emotional Intelligence).

The multiple comparisons of body image satisfaction, gender, and their interaction indicate that children who are satisfied with their body image obtained higher scores ($p \leq 0.05$) than people who were very dissatisfied in the interpersonal, adaptability, stress management, and mood components of emotional intelligence, although in the component stress management, the differences between satisfied and very dissatisfied individuals were only significant in boys, with no differences ($p \leq 0.05$) in stress management as a function of body image satisfaction among girls. On the other hand, the subsequent inter-subject analysis of gender effects revealed significant differences in interpersonal components and stress management, such that girls scored higher ($p \leq 0.05$) than boys in all the paired comparisons of body image satisfaction (satisfied, dissatisfied, or very dissatisfied), except for the comparison between boys and girls who were satisfied with their body image in the interpersonal component, where no differences were found ($p \leq 0.05$) between boys and girls.

4. Discussion

The main objective of this study was to analyze the differences in the intrapersonal, interpersonal, stress management, adaptability, and mood dimensions of emotional intelligence in childhood as a function of the children's degree of body image satisfaction and gender. Based on this aim, the hypothesis proposed is that participants who show greater satisfaction with their body image will have higher levels of emotional intelligence.

As a starting point and a relevant general fact, the results show that 76% of the children are not satisfied with their body image: the girls want to be thinner and the boys prefer to have a more athletic build. These results could be explained partly by the age of the sample, as a preadolescent stage where children are starting to mature, with all the changes that this entails in their body. In fact there are more and more studies that show neurobiological and social contextual factors that could influence the development of social cognition and behavior during adolescence and puberty [28]. However, if we focus on today's society this indicates that children rate their body negatively, influenced by the aesthetic ideal implanted in contemporary society [21], which rewards thinness in the female body and musculature in the male body, moreover, seeking beauty and absolute perfection [22,23].

These data are alarming, taking into account the studies that have shown that body dissatisfaction is linked to negative and maladaptive consequences of children's behavior, such as the development of eating behavior disorders [16,17], and low levels of physical activity [29]. Therefore, before such dissatisfaction can lead to behaviors that are consolidated and harmful for children's health, it is necessary to intervene in the schools, where the subject of Physical Education could be a crucial aspect [30,31].

However, if we focus on the age of the sample, as a preadolescent stage, we must consider that children are starting to mature, with all the changes that this entails in their body. Focusing on the hypothesis of the present study, the results show that, regardless of gender, children who have better emotional and social competencies, greater adaptability, and better mood are also more satisfied with their body image, so the hypothesis can be confirmed. That is, children who are satisfied with their body image have greater skills to understand and appreciate the emotions of others, greater flexibility and effectiveness to resolve conflicts, and a more positive life attitude, and therefore, they can better control their emotions. In line with these findings, it has been shown that emotions, perceptions, and thoughts are interconnected [18,19], so if we learn to control our emotions and extract relevant information, this affects the creation of more accurate, precise, and positive perceptions and thoughts [20].

However, the results indicate that, regardless of the level of satisfaction with body image, girls show higher stress management than boys. These findings seem to be influenced by age because, in adolescence, girls show higher levels of stress perception [32,33] so, considering the stage in which the present study is contextualized (encompassing childhood and preadolescence) as well as girls' early maturation compared to boys, girls' greater perception of stress may be related to the physiological, psychological, and social changes they are experiencing [34]. These gender differences in the perception of stress have been explained by biology and by the expectations of the society in which girls are born [35], where women are expected to present great skills within and outside of the educational context and to tend toward self-perfection [36]. These demands have contributed to women's learning to self-manage in order to cope with everything and improve their individual performance each day, so that they are more likely to manage their stress better and to present higher self-esteem due to their performance in all their settings [33].

5. Limitations

One of the main limitations of the study is that we did not really measure the students' size or weight. This prevents knowing whether their body image satisfaction/dissatisfaction was only a perception provoked by the need to meet the aesthetic ideals implanted in the present society or it was a realistic perception, where their weight is far from the average weight established for people of their age and gender. Therefore, it would be necessary to complement the measure of body image satisfaction/dissatisfaction with the real measure of the children's size and weight to determine whether or not they have health problems which should be resolved more urgently and from other approaches.

On the other hand, it should be noted that a research sample is a possible limitation in terms of reliability of information, because it cannot be generalized to other types of populations or children with different ages.

6. Conclusions

The following main conclusions of this work can be reached: (1) 76.3% of the children participating in this research are not satisfied with their figure, the boys want to have a more athletic build; (2) children who are satisfied with their body image show more emotional skills to relate with others, greater adaptability to any situation, and better mood; (3) girls have a greater ability to manage stress and have more emotional control than boys.

With a view to subsequent studies, as primary and secondary education is compulsory and can reach all the children and young people, it would be necessary to promote training and intervention programs to prevent body image dissatisfaction, imparted by psychologists, graduates in sports sciences, nutritionists, and even doctors. The objective would be to raise the awareness of the entire educational community (students, teachers, and parents) and to implement practical strategies to maintain the body that we desire in a healthy way, through eating habits (by offering healthy menus at school) and the practice of physical activity.

In order to awaken interest in these kinds of programs and make them effective, they must be adapted to the demands of contemporary society. Therefore, the use of new technologies could be applied, such as the creation of educational blogs in which students participate actively or the use of mobile applications for adequate consumption of food and for the practice of physical activity [37,38]. It is also interesting for participants to experience all this in workshops designed by specialists in each of the affected areas, so that prevention is reinforced with active, cooperative, and collaborative learning.

The main contribution of this study to the scientific literature is that most of the studies carried out have observed the influence of emotional intelligence on body satisfaction (usually linked to eating disorders). However, in this study we observed how body satisfaction and gender can modulate emotional intelligence, specifically studying psychological variables, the way people perceive, feel, and behave in relation to their own body. Thereby, we could promote training and intervention programs at schools to promote good emotional and social skills in children.

Author Contributions: Conceptualization, B.L.-d.-B. and D.I.G.; Formal analysis, S.M.-L.; Methodology, B.L.-d.-B. and D.I.G.; Resources, D.A.A.; Supervision, D.I.G.; Writing—original draft, D.A.A.; Writing—review & editing, D.A.A. and D.I.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: The authors would like to thank the participation of teachers and pupils in this study.

Conflicts of Interest: The authors declare no conflict of interest.

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A Two-Stage MCDM Model for Exploring the Influential Relationships of Sustainable Sports Tourism Criteria in Taichung City

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Received: 11 March 2020; Accepted: 27 March 2020; Published: 30 March 2020

Abstract: Many countries advocate sports for all to cultivate people's interest in sports. In cities, cross-industry alliances between sports and tourism are one of the common practices. The following two important issues need to be discussed, namely, what factors should be paid attention to in the development of sports tourism, and what are the mutual influential relationships among these factors. This study proposes a novel two-stage multi-criteria decision-making (MCDM) model to incorporate the concept of sustainable development into sports tourism. First, the Bayesian best–worst method (Bayesian BWM) is used to screen out important criteria. Bayesian BWM solves the problem of expert opinion integration of conventional BWM. It is based on the statistical probability to estimate the optimal group criteria weights. Secondly, the rough decision making trial and evaluation laboratory (rough DEMATEL) technique is used to map out complex influential relationships. The introduction of DEMATEL from the rough set theory has better practicality. In the calculation program, interval types are used to replace crisp values in order to retain more expert information. A city in central Taiwan was used to demonstrate the effectiveness of the model. The results show that the quality of urban security, government marketing, business sponsorship and mass transit planning are the most important criteria. In addition, in conjunction with local festivals is the most influential factor for the overall evaluation system.

Keywords: sustainable sports tourism; sports for all; MCDM; Bayesian BWM; rough DEMATEL

1. Introduction

Including some sports activities or watching sports events in the tourist itinerary has become one of the major development projects of the tourism industry [1]. Sports tourism is defined as "combining sports events with tourism" and can be divided into six types, including sports events, sports resorts, sports cruises, sports attractions, sports adventures and sports tours [2]. Many studies have pointed out that organizing related sports tourism in cities is conducive to the development of social image and local economy. For this reason, many cities have also set up special organizations to organize sports events to increase regional exposure and sports image [3,4]. Many countries are actively seeking viable marketing strategies to attract foreign and domestic tourists to travel there. The most typical way is to increase the number of tourists by using sports events. For example, in 2017, Taipei hosted a 13-Erlenmeyer-day Universiade and sold a total of 720,000 tickets to the sports event. This event not only attracted more foreign tourists but also promoted the local culture of Taipei. In addition, some well-known cities have been successfully transformed into sports tourism attractions and have established their image as sports cities. For example, Perth is known as the City of Sporting Events, Lausanne is known as Olympic Capital City and Lake Placid is billed as the Winter Sports Capital of the United States [2].

Due to abnormal climate change and frequent natural disasters, many international organizations (such as the World Health Organization (WHO), European Union (EU) and World Trade Organization (WTO)) have called on all industries to pay attention to "sustainable development" and formulated many regulations and agreements on environmental protection [5]. Therefore, the tourism industry is also actively moving towards the developmental vision of sustainable tourism and many kinds of research on sustainable sports tourism have been released. Gibson et al. [6] explored the cooperation between six small-scale sports events and local sports agencies (the evaluation includes economic, social and environmental protection aspects) and surveyed 447 sports event participants and spectators in terms of sports planning satisfaction. Pouder et al. [3] used expert interviews to explore how for-profit organizations can develop the market for sports tourism. Their study is particularly focused on economic development, with the goal of maximizing returns. Gil-Alana et al. [4] examined whether fluctuations in financial exchange rates have a significant impact on the returns of Brazilian sports tourism. The study used a multiple linear regression model to analyze the structure of tourism revenue structure over 20 years. Hsu et al. [7] developed an island-type sustainable tourism attitude scale focusing on the environmental protection perspective of sports attractions. Their data came from a survey of three islands in Taiwan. The results show that local culture and environmental protection are the most important factors in tourism development.

It is an important task to develop an effective urban tourism development evaluation model [8,9]. Multi-criteria decision-making (MCDM) is widely used in various evaluation and selection problems and it has excellent evaluation performance under many constraints. In contrast to statistical methods, MCDM does not need to establish basic assumptions for criteria or variables. MCDM has developed many soft calculation methods to process a variety of complex data (including data from expert interviews and data from actual surveys) and provide valuable management information to support decision-makers in formulating optimal strategies [10–13]. At present, there have been some studies using MCDM to study tourism-related issues, such as surveys of service quality in tourism [14], hotel performance evaluation and selection [15], tourism development and management [16].

According to the literature review, the evaluation system of urban sustainable sports tourism for cities has not been established yet. The purpose of this study is to propose a novel two-stage MCDM model to establish the evaluation criteria for cities to develop sustainable sports tourism and to explore the mutual influential relationships among the criteria. The evaluation framework is new, and the proposed hybrid methodology has not appeared. In summary, this model brings some contributions and innovations to sustainable tourism development for the cities:

(i) The traditional sustainability concept revolves around social (S), environmental (B) and economic (C). The addition of "institutional sustainability (I)" makes the evaluation structure more complete;
(ii) Bayesian best–worst method (Bayesian BWM) [17] is used as a criteria screening method. Compared to the analytic hierarchy process (AHP), the number of pairwise comparisons questionnaire content in the Bayesian BWM is significantly reduced and it has better consistent results;
(iii) In the calculation of DEMATEL, it combines rough set theory to optimize the applicability of the conventional DEMATEL;
(iv) The mutual influential relationships among the criteria are identified using rough DEMATEL to support decision-makers in developing urban sports tourism development strategies;
(v) The proposed methodology is not limited to any industry and various industries can imitate and develop their own decision-making systems.

The rest of this article is organized as follows. Section 2 briefly reviews the literature on sports tourism and presents the proposed evaluation framework for sustainable urban sports tourism development. Section 3 introduces the proposed two-stage MCDM model, including the implementation steps of Bayesian BWM and rough DEMATEL. Section 4 presents a real case in Taiwan to illustrate the feasibility and practicality of the proposed model. Section 5 includes discussions and management implications. Section 6 presents concludes with conclusions and future research.

2. Literature Review for Sustainable Sports Tourism Evaluation Criteria

Many countries promote sports tourism by joining sports, setting up specialized sports tourism agencies whether in large cities or local towns [3,18]. Sports tourism is a special type of tourism that provides tourists with an active (active participation in sports events as competitors) or passive (passive participation in sports events as spectators) experience that is different from traditional tourism. People interact with events, people and places when participating in sports tourism-related events [19]. Kim et al. [20] pointed out that large-scale sports tourism activities can attract many domestic and foreign participants and spectators; these sports events can increase local income and opportunities for urban development. On the contrary, these events also have negative impacts, that is, traffic congestion, environmental pollution, safety issues and damage to residents' rights. Therefore, the concept of sustainable development combined with research on tourism has been proposed. Nunkoo et al. [21] emphasized that the establishment of public trust and the formulation of environmental protection policies can develop excellent urban tourism. Gkoumas [22] proposes a comprehensive assessment index for sustainable tourism for the Mediterranean tourism industry; local governance is the most critical factor for the development of sports tourism. Musavengane et al. [23] explored the security of tourism in African countries, holding that cultural tolerance, local security, medical and rescue flexibility and the integrity of environmental awareness are all key items for evaluation. Yang et al. [24] first proposed a complete MCDM model of sustainable sports tourism, which established an effective evaluation system for tourist attractions in central Taiwan. Unfortunately, to our knowledge, no article has been conducted to examine the performance of sustainable sports tourism in the cities. In addition, the mutual influential relationships among evaluation criteria have not been explored.

This study proposes a novel evaluation framework to determine the evaluation criteria and their mutual influential relationships. For cities to develop sustainable sports tourism, they must receive support from local governments and the tourism industry. First, important criteria should be fully integrated into the evaluation system to reflect the characteristics and connotation of sports tourism. The initial criteria review was based on relevant academic literature [3,8,9,18,19,24] and expert interviews (a decision group was formed, including tourism industry, Taiwan Tourism Bureau, local government and environmental protection experts). The main framework includes four dimensions, namely social (S), environmental (G), economic (E) and institutional (I). Each of these four dimensions contains several criteria and a total of 30 evaluation criteria are included in the evaluation framework. The criteria, descriptions and literature are shown in Table 1.

Table 1. Evaluation criteria and descriptions.

Dimension	Criteria	Description	References
Social (S)	Strengthening the image of the city (S1)	The culture of the region will affect the development of sports; it is necessary to strengthen the image of the city.	[9,18,19]
	Maintaining the lifestyle of urban residents (S2)	While promoting urban sports tourism, it is necessary to ensure that it does not affect the original lifestyle and quality of residents.	[18,19,22,24]
	Providing additional benefits for urban area residents (S3)	Providing additional benefits or subsidy programs for local residents, so that residents can better accept sports events and provide assistance.	[18,19,24]
	Promoting social equity (S4)	Respecting for equality and protection of participation rights of disadvantaged ethnic groups.	[18,19,24]
	Insuring for participants (S5)	Insuring for each participant and staff.	[18]
	Actively donating part of the income to public welfare (S6)	Some of the incomes from sports events will be donated to social welfare or public welfare organizations.	[18,19]
	Formulating procedures for handling emergencies (S7)	Prior to the event, all emergency situations must be prepared; handling procedures must be carefully planned.	[18,19,24]
	Maintaining the quality of urban public order (S8)	Paying attention to the law and order of the city to ensure that all event personnel can feel safe and secure.	[18,22,24]
Environmental (G)	Using the city's existing infrastructure (G1)	New facilities or buildings should not be built for sporting events. The existing facilities should be used to maintain the original look of the city.	[3,9,18,19,24]
	Compliance with environmental protection regulations (G2)	All activities must be prepared in an environmentally friendly manner and must be as natural as possible.	[8,9,18,19,24]
	Developing protection measures for natural ecological areas (G3)	Establishing protection regulations for the city's natural ecological area to ensure that the area is not damaged by activities.	[8,9,18,24]
	Restrictions on plastic materials (G4)	Consumables and items used in the event shall be controlled according to the amount of consumed plastic materials.	[9,18,19,24]
	Well-planned urban cleanup plan (G5)	Sports events bring crowds and waste; a complete cleaning plan should be developed to maintain the cleanliness of the city.	[8,9,18,24]
	Planning the city's mass transit system (G6)	A sound mass transit system can effectively reduce the problem of traffic congestion and reduce carbon emissions from self-driving cars.	[8,9,19]
	Controlling noise pollution (G7)	Gathering of people will generate huge noise; noise control should be done at specific times and places.	[9]
	Monitoring the quality of drinking water (G8)	The source of drinking water and the filtration system should be controlled in detail to ensure the water quality of the participants.	[8]

Table 1. *Cont.*

Dimension	Criteria	Description	References
Economic (E)	Providing information on accommodation in the city (E1)	Providing complete accommodation and related information to facilitate participants in planning their accommodation.	[18,19]
	Providing information on dining in the city (E1)	Providing comprehensive dining information and presenting local food and beverage to tourists from other places.	[18,19]
	Providing information on attractions & shopping in the city (E2)	Providing information on places that can be visited during non-match times, allowing participants to flexibly arrange their free time.	[18,19]
	Increasing employment opportunities for urban residents (E4)	Local residents serve as staff during sports events, increasing employment opportunities for local residents.	[8,9,18,24]
	Sponsorship and support from local businesses (E5)	Local companies support the development of urban sports and provide more event sponsorship, funding and assistance.	[3]
	Sponsored Brand Exposure (E6)	Logos of sponsoring companies are placed in or around the venue, or sports merchandises are provided by the brands.	[3]
	Increasing the number of visits to the attractions in the city (E7)	Enhancing the richness of attractions around the city to attract more people and increase visits.	[9,24]
Institutional (I)	Combined with smart wearable device (I1)	Smart devices are used in sports events to monitor the physiological status and conditions of the contestants.	Experts' opinions
	Maintenance of urban tourism website (I2)	Maintaining and updating information on urban sports events.	[3,19]
	Enhancing participant reward system (I3)	Increasing the prizes and bonuses of the event to increase participants' willingness to participate.	[18,19]
	In conjunction with festivals in the city (I4)	Urban sports events combined with local festivals and events can bring participants richer experiences.	[9,18,24]
	Promotion of urban culture and heritage (I5)	Developing plans for the promotion of the city's historical culture and heritage.	[8,9,24]
	Land planning for sports events (I6)	Drawing up complete protection measures for the event venue and clearly marking the event areas and related events.	[8,24]
	Marketing and promotion by local governments (I7)	Local governments organize sporting events from time to time and plan marketing strategies.	[3,24]

Source: authors' own compilation.

3. The Proposed Two-Stage MCDM Model

The chosen case is Taichung City, Taiwan. The Taichung City Government actively promotes sports infrastructure and promotes the correct sports concept to implement "sports for all ages". In December 2019, the Taichung City Sports Bureau decided to organize marathons to connect the sports events with local specialties in order to serve the purpose of marketing the city and promoting culture. In 2020 alone, Taichung City has already prepared at least 35 marathon events. However, building an image of a sports city is a difficult and complex project; many factors and restrictions must be considered, including economic feasibility, social development, environmental awareness and policy support. Only through continuous review and improvement can we move towards the vision of urban sports for all ages. At present, there has not been a sustainable sports tourism evaluation system developed specifically for the cities. In addition, most studies have not examined the mutual influential relationships among criteria. Which evaluation criteria are the main factors that affect the success or failure of urban sports tourism? How do these criteria affect other criteria? These two issues are the focal points of this study.

In the study, the decision-making team consisted of ten experts, including tourism managers, members of the Ministry of Tourism and academics. These ten experts have at least 8 years of qualifications in sports events or tourism-related jobs; their current jobs are highly relevant to the development of sports tourism. The proposed evaluation framework is presented in Sections 2 and 4 dimensions with 30 criteria classified under them were identified.

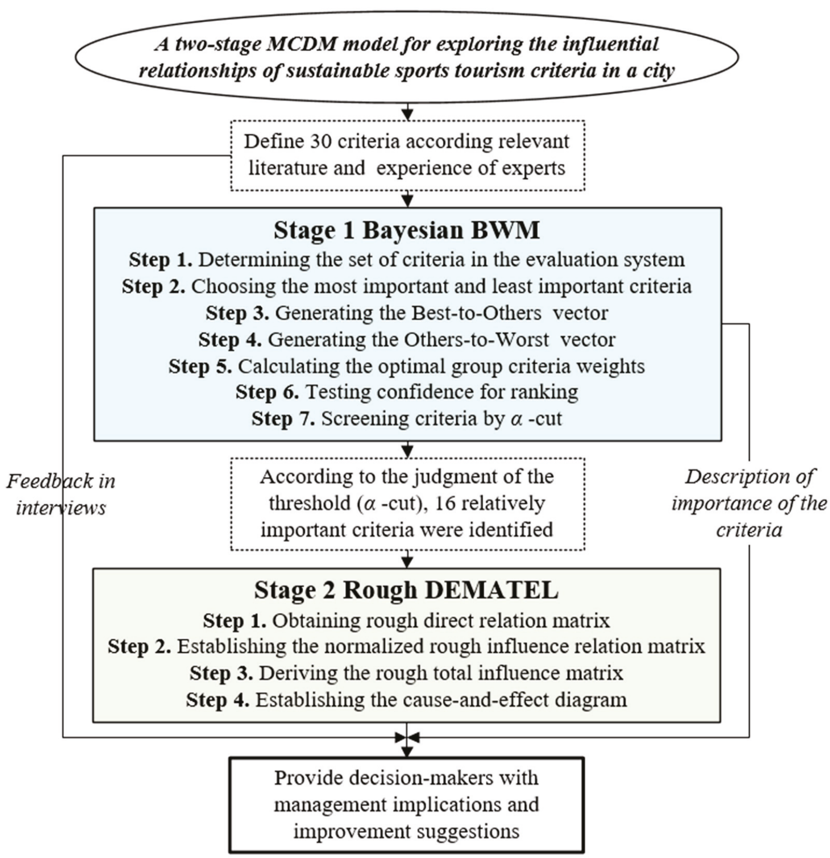

Figure 1. The analysis procedure diagram.

Next, we describes the method used and its detailed calculation process. In the first stage, preliminary evaluation criteria were established based on the literature discussions on sports tourism and sustainable tourism. Due to the large number of evaluation criteria, screening must be performed to retain key criteria. Based on the interview data of several experts, the Bayesian BWM was used to calculate the weight of criteria and select the key criteria. Bayesian BWM—proposed by Mohammadi and Rezaei [17]—effectively integrates the judgments of multiple experts and shortens the computational procedures of the conventional BWM. In the second stage, the rough decision making trial and evaluation laboratory (rough DEMATEL) technique is used to map a cause-and-effect diagram of criteria to examine the strength of the influential relationship among the criteria. This study combines rough set theory with conventional DEMATEL. On the one hand, the consensus of the decision-making group can be known. Moreover, the interval value operation can be retained to avoid the loss of information. The analysis procedure diagram of this study is shown in Figure 1.

3.1. Stage 1: Bayesian BWM

Bayesian BWM effectively integrates the opinions of multiple experts to generate a set of optimal group criteria weights. Its survey process is simple and intuitive. Experts are asked to choose the most important and least important criteria; then they are compared pairwise with other criteria to form a structured set of two vectors. Based on the concept of statistical distribution, the optimal group criteria weights are estimated. The detailed Bayesian BWM derivation and proof can be found in the study of Mohammadi and Rezaei [17]. The implementation steps of Bayesian BWM are explained as follows:

3.1.1. Step 1. Determining the Set of Criteria in the Evaluation System

The evaluation criteria $\{c_1, c_2, \ldots, c_n\}$ were identified through literature review and multiple expert interviews.

3.1.2. Step 2. Choosing the Most Important and Least Important Criteria

Based on the set of criteria, each expert chooses what s/he considers the most important and least important criteria.

3.1.3. Step 3. Comparing the Most Important Criteria with Other Criteria to Generate the BO (Best-to-Others) Vector

Each expert evaluates the relative importance of the most important criteria to other criteria to generate the BO vector. The ratings of BWM are shown in Table 2.

$$A_{Bj} = (a_{B1}, a_{B2}, \ldots, a_{Bn}) \tag{1}$$

where a_{Bj} indicates the importance of the most important criterion B relative to criterion j.

Table 2. BWM evaluation ratings.

Linguistic Variable	Crisp Value
Equally important	1
Equal to moderately more important	2
Moderately more important	3
Moderately to strongly more important	4
Strongly more important	5
Strongly to very strongly more important	6
Very strongly more important	7
Very strongly to extremely more important	8
Extremely more important	9

3.1.4. Step 4. Comparing Other Criteria with the Least Important Criteria to Generate the OW (Others-to-Worst) Vector

Similar to Step 3, each expert evaluates the relative importance of the other criteria to the least important criteria to generate the OW vector.

$$A_{jW} = (a_{1W}, a_{2W}, \ldots, a_{nW})^T \tag{2}$$

where a_{jW} indicates the importance of the other criterion j relative to the least important criterion W.

3.1.5. Step 5. Calculating the Optimal Group Criteria Weights

Each expert follows Step 1 to Step 4 to get multiple sets of BO and OW vectors. According to the MATLAB program software provided by Mohammadi and Rezaei [17], the evaluation scores of all experts are used as input data to obtain the optimal group criteria weights.

3.1.6. Step 6. Testing Confidence for Ranking

After the weights are obtained, it must be checked whether the ranking of the weight is consistent. Assume that the two criteria in the criteria set are c_i and c_j and use the concept of Credal Ranking to test their confidence. Then the probability that c_i is better than c_j is

$$P\left(c_i > c_j\right) = \int I\left(w_i^{agg} > w_j^{agg}\right) P\left(w^{agg}\right) \tag{3}$$

where w^{agg} is the group criteria weight, $P(w^{agg})$ is the posterior probability of w^{agg} and I is the condition parameter, which can be calculated when $\left(w_i^{agg} > w_j^{agg}\right)$ is true, otherwise it is 0. The Markov-chain Monte Carlo (MCMC) technique is used to perform multiple simulations and the number of samples Q obtained by it is used to calculate its average confidence level.

$$\begin{aligned} P\left(c_i > c_j\right) &= \frac{1}{Q}\sum_{q=1}^{Q} I\left(w_i^{agg_q} > w_j^{agg_q}\right); \\ P\left(c_j > c_i\right) &= \frac{1}{Q}\sum_{q=1}^{Q} I\left(w_j^{agg_q} > w_i^{agg_q}\right) \end{aligned} \tag{4}$$

where w^{agg_q} represents q w^{agg} s from the MCMC sample. When $P\left(c_i > c_j\right) > 0.5$, it indicates that criterion i is more important than criterion j and the probability presented is the confidence level. In addition, the total probability is 1, $P\left(c_i > c_j\right) + P\left(c_j > c_i\right) = 1$.

3.1.7. Step 7. Screening Criteria by α-cut

The α-cut is the threshold value of the screening criteria. There are n criteria in the criteria set, $\{c_1, c_2, \ldots, c_n\}$. α-cut is shown below.

$$\alpha\text{-cut} = \frac{1}{n} \tag{5}$$

This step can distinguish the relatively important and relatively unimportant criteria groups. We retain the rules that are larger than α-cut.

3.2. Stage 2: Rough DEMATEL

DEMATEL technique was proposed by Battelle Memorial Institute in 1972. This method is used to solve the problem of the complex structures in real society [25]. DEMATEL aims to establish a structure diagram that can show mutual influential relationships among the criteria. It is called a cause-and-effect diagram, which effectively supports decision-makers in understanding the interaction and influence relationships in the entire system. The conventional DEMATEL uses arithmetic average method to integrate evaluation data from multiple experts. This study combines rough set theory with DEMATEL, called rough DEMATEL or R-DEMATEL. This method not only can know the consensus degree of the decision-making group, but also retain the calculation of interval values to avoid the loss of information. The calculation steps of the rough number can be found in Lo et al. [26] and Chang et al. [27]. We use a simple example to illustrate how to integrate the rough number calculations of multiple experts. Assume that the evaluation values of the five experts in evaluating event A are 4, 4, 3, 2 and 2, respectively, then lower and upper bounds of rough numbers ($\underline{Lim}$ and $\overline{Lim}$) are

$$\underline{Lim}(4) = (4+4+3+2+2)/5 = 3,\ \overline{Lim}(4) = (4+4)/2 = 4$$
$$\Rightarrow \tilde{A}^{(1)} = \tilde{A}^{(2)} = \tilde{4} = [3,\ 4];$$

$$\underline{Lim}(3) = (3+2+2)/3 = 2.333,\ \overline{Lim}(3) = (3+4+4)/3 = 3.667$$
$$\Rightarrow \tilde{A}^{(3)} = \tilde{3} = [2.333,\ 3.667];$$

$$\underline{Lim}(2) = (2+2)/2 = 2,\ \overline{Lim}(2) = (4+4+3+2+2)/5 = 3$$
$$\Rightarrow \tilde{A}^{(4)} = \tilde{A}^{(5)} = \tilde{2} = [2,\ 3].$$

where the symbol "~" indicates that those are rough numbers. This set of scores can be obtained by averaging as follows:

$$\tilde{A} = [(3+3+2.333+2+2)/5,\ (4+4+3.667+3+3)/5] = [2.467,\ 3.533].$$

After screening criteria by Bayesian BWM, the rough DEMATEL procedure is further performed. The detailed steps are stated below:

3.2.1. Step 1. Obtaining Rough Direct Relation Matrix $\tilde{\boldsymbol{Q}}$

After screening, there are n^* criteria and each expert evaluates the direct impact of the criteria i on the criteria j according to DEMATEL's evaluation ratings (Table 3). Then, the subjective opinions of all experts will be converted into a set of interval-type interval numbers by the rough number operation in rough theory and a rough direct relation matrix $\tilde{\boldsymbol{Q}}$ can be obtained. As shown in Equation (6).

$$\tilde{\boldsymbol{Q}} = [\tilde{q}_{ij}]_{n^*\times n^*}, i = j = 1, 2, \ldots, n^* \tag{6}$$

where $\tilde{q}_{ij} = [q^L_{ij}, q^U_{ij}]$.

Table 3. DEMATEL's evaluation ratings.

Linguistic Variable	**Crisp Value**
No influence	0
Low influence	1
Medium influence	2
High influence	3
Very high influence	4

3.2.2. Step 2. Establishing the Normalized Rough Influence Relation Matrix $\tilde{\boldsymbol{D}}$

The rough direct relation matrix $\tilde{\boldsymbol{Q}}$ can obtain a normalized rough influence relation matrix $\tilde{\boldsymbol{D}}$ through Equations (7) and (8). The normalized program can convert the evaluation value to between 0 and 1.

$$\tilde{\boldsymbol{D}} = \varepsilon \times \tilde{\boldsymbol{Q}} \tag{7}$$

$$\varepsilon = \min\left\{1/\max_i \sum_{j=1}^{n^*} q_{ij}^U, 1/\max_j \sum_{i=1}^{n^*} q_{ij}^U\right\}, i = j = 1, 2, \ldots, n^* \tag{8}$$

where $\tilde{\boldsymbol{D}} = [\tilde{d}_{ij}]_{n^* \times n^*}$, $0 \leq \tilde{d}_{ij} < 1$ and $\tilde{d}_{ij} = \left[d_{ij}^L, d_{ij}^U\right]$. In $\sum_{j=1}^{n^*} d_{ij}^U$ and $\sum_{i=1}^{n^*} d_{ij}^U$, the sum of any row or column is less than or equal to 1.

3.2.3. Step 3. Deriving the Rough Total Influence Matrix $\tilde{\boldsymbol{T}}$

The normalized rough influence relation matrix $\tilde{\boldsymbol{D}}$ uses Equation (9) to calculate the degree of each direct influence relationship and indirect influence relationship ($\boldsymbol{I}$ is the identity matrix) and finally integrates a rough total influence matrix $\tilde{\boldsymbol{T}}$ as shown in Equation (10).

$$\begin{aligned} \tilde{\boldsymbol{T}} &= \tilde{\boldsymbol{D}} + \tilde{\boldsymbol{D}}^2 + \cdots + \tilde{\boldsymbol{D}}^{\Theta} = \tilde{\boldsymbol{D}}\left(\boldsymbol{I} + \tilde{\boldsymbol{D}} + \tilde{\boldsymbol{D}}^2 + \cdots + \tilde{\boldsymbol{D}}^{\Theta-1}\right) \\ &= \tilde{\boldsymbol{D}}\left(\boldsymbol{I} - \tilde{\boldsymbol{D}}^{\Theta}\right)\left(\boldsymbol{I} - \tilde{\boldsymbol{D}}\right)^{-1} = \tilde{\boldsymbol{D}}\left(\boldsymbol{I} - \tilde{\boldsymbol{D}}\right)^{-1}, \text{when } \Theta \to \infty, \tilde{\boldsymbol{D}}^{\Theta} = [0]_{n^* \times n^*} \end{aligned} \tag{9}$$

$$\tilde{\boldsymbol{T}} = [\tilde{t}_{ij}]_{n^* \times n^*} \tag{10}$$

where $\tilde{t}_{ij} = \left[t_{ij}^L, t_{ij}^U\right]$.

3.2.4. Step 4. Establishing the Cause-and-Effect Diagram

The rough total influence matrix $\tilde{\boldsymbol{T}}$ can obtain the degree of rough affecting relationship ($\tilde{\boldsymbol{s}}_i$) and the degree of rough affected relationship ($\tilde{\boldsymbol{o}}_i$) of each criterion through Equations (11) and (12).

$$\tilde{\boldsymbol{s}} = [\tilde{s}_i]_{n^* \times 1} \tag{11}$$

$$\tilde{\boldsymbol{o}} = [\tilde{o}_j]_{1 \times n^*}^T = [\tilde{o}_i]_{n^* \times 1} \tag{12}$$

where the symbol "*T*" stands for transpose. In addition, $\tilde{s}_i = \left[\sum_{j=1}^{n} t_{ij}^L, \sum_{j=1}^{n} t_{ij}^U\right]$ and $\tilde{o}_j = \left[\sum_{i=1}^{n} t_{ij}^L, \sum_{i=1}^{n} t_{ij}^U\right]^T$.

The $\tilde{s}_i + \tilde{o}_i$ represents the rough total influence of the criterion within the evaluation system, and is called the prominence. $\tilde{s}_i - \tilde{o}_i$ represents the rough net influence of the criterion within the evaluation system and is called the net cause-effect. If $\tilde{s}_i - \tilde{o}_i > 0$, it represents the degree of rough net influence of the criterion on other criteria; on the contrary, if $\tilde{s}_i - \tilde{o}_i < 0$ it represents the degree of rough net influence of the criterion by other criteria. The detailed cause-and-effect diagram results are presented in Section 4.2.

4. Empirical Example

Participating in sports activities not only can promote the physical health of people of all ages, but also bring social benefits and improve people's happiness. Healthy people will be the biggest asset of a country; the physical fitness of the people will be the foundation of the country's competitiveness. Moderate exercise promotes physiological metabolism and helps to resist stress. In order to enhance the country's sports competitiveness and protect people's sports rights, the promotion of sports has become the focal policy of advanced countries to learn and observe from each other. In Taiwan, the most common sports activities include outdoor leisure sports, ball sports, stretching, dancing, water sports and so on. Among them, outdoor leisure sports account for more than 80% of total sports events [28]. Therefore, the sports projects that this study explores to promote sustainable sports tourism are mainly outdoor leisure sports. This section introduces the background of the case, as well as the practical application of Bayesian BWM and rough DEMATEL.

4.1. Screening the Criteria by Using Bayesian BWM

Based on the Bayesian BWM calculation described in Section 3.1, first, each expert was required to make pairwise comparisons of the criteria in each dimension. A total of four BWM questionnaires needed to be filled out. Since the function of Bayesian BWM at this stage is for screening criterion, there is no need to perform pairwise comparisons for the dimensions. Consistency ratio (CR) was performed on the recovered BWM questionnaires to check the logic of the experts in the response process. Based on the consistency test formula proposed by Rezaei [29], the average CR value in the study is 0.014 (with high consistency). Table 4 lists the optimal group criteria weights. According to the judgment of the threshold (α-cut), 16 relatively important criteria were identified, which are important factors for the sustainable development of urban tourism, including S6, S7, S8, G1, G2, G4, G6, G8, E4, E5, E6, E7, I1, I2, I4 and I7. The mutual influential relationships of these criteria included in the evaluation system were analyzed by the rough DEMATEL technique.

Table 4. Criteria weights obtained through Bayesian BWM.

Dimension	Criteria (Weight)	Ranking	Dimension	Criteria (Weight)	Ranking
Social (S)	S1 (0.086)	7	**Environmental (G)**	G1 (0.129) *	4 *
	S2 (0.087)	6		G2 (0.137) *	3 *
	S3 (0.090)	5		G3 (0.070)	8
	S4 (0.116)	4		G4 (0.182) *	2 *
	S5 (0.054)	8		G5 (0.075)	7
	S6 (0.143) *	3 *		G6 (0.203) *	1 *
	S7 (0.202) *	2 *		G7 (0.078)	6
	S8 (0.223) *	1 *		G8 (0.126) *	5 *
	α-cut = 0.125			α-cut = 0.125	
Economic (E)	E1 (0.096)	5	**Institutional (I)**	I1 (0.194) *	3 *
	E2 (0.090)	6		I2 (0.150) *	4 *
	E3 (0.083)	7		I3 (0.071)	7
	E4 (0.196) *	2 *		I4 (0.204) *	2 *
	E5 (0.204) *	1 *		I5 (0.086)	5
	E6 (0.165) *	4*		I6 (0.074)	6
	E7 (0.167) *	3 *		I7 (0.220) *	1 *
	α-cut = 0.143			α-cut = 0.143	

Note: The "*" symbol represents the criteria that exceed the threshold value. These criteria would be calculated by DEMATEL.

In order to check whether the weights obtained, and the ranking are reliable, a ranking confidence test is performed. Among the four dimensions, their confidence levels of ranking are 0.926, 0.871, 0.868 and 0.904, respectively. It represents the criteria ranking in each dimension is highly confident. Next, rough DEMATEL analysis was performed on the criteria incorporated in the evaluation system.

This study also compared the criteria screening results of AHP, conventional BWM and Bayesian BWM, as shown in Table 5.

Table 5. Criterion screening results for three different methods.

Method	(Criteria Through Screening)
AHP	S6, S7, S8, G1, G2, G4, G6, E4, E5, E6, E7, I1, I4 and I7
BWM	S6, S7, S8, G1, G2, G4, G6, E4, E5, E6, E7, I1, I4 and I7
Bayesian BWM (This study)	S6, S7, S8, G1, G2, G4, G6, G8, E4, E5, E6, E7, I1, I2, I4 and I7

AHP and BWM have fewer screening criteria than Bayesian BWM (without G8 and I2). This is because AHP and BWM use arithmetic averages when integrating experts' opinions. This method is vulnerable to the influence of extreme values, resulting in the loss of some information. In contrast, Bayesian BWM, which pays extra consideration for G8 and I2, makes the influential relationship system of the criteria more complete. It must be noted here that I2 and G8 are important affecting and affected factors in the analysis of rough DEMATEL.

4.2. Obtaining the Cause-and-Effect Diagram by Using Rough DEMATEL

The implementation process of rough DEMATEL is explained in Section 3.2. The data of 10 experts' surveys are calculated according to this process to obtain the rough influence degree of each criterion, as shown in Table 6.

Table 6. Sum of the defuzzification of rough influences given and received by criteria.

	$\tilde{s}_i$	$\tilde{o}_i$	$\tilde{s}_i+\tilde{o}_i$	$\tilde{s}_i-\tilde{o}_i$	s_i	o_i	s_i+o_i	s_i-o_i
S6	[0.581, 2.551]	[0.759, 2.539]	[1.340, 5.090]	[−1.958, 1.792]	1.566	1.649	3.215	−0.083
S7	[0.424, 2.055]	[0.828, 2.848]	[1.252, 4.903]	[−2.423, 1.228]	1.240	1.838	3.078	−0.598
S8	[0.788, 3.000]	[0.895, 3.116]	[1.683, 6.116]	[−2.328, 2.105]	1.894	2.006	3.900	−0.112
G1	[0.866, 3.011]	[0.755, 2.873]	[1.621, 5.884]	[−2.007, 2.256]	1.939	1.814	3.753	0.125
G2	[0.790, 2.761]	[0.891, 2.850]	[1.681, 5.611]	[−2.059, 1.870]	1.776	1.870	3.646	−0.095
G4	[0.466, 2.112]	[0.643, 2.413]	[1.109, 4.525]	[−1.947, 1.468]	1.289	1.528	2.817	−0.240
G6	[0.740, 2.935]	[1.129, 3.476]	[1.869, 6.411]	[−2.736, 1.806]	1.837	2.303	4.140	−0.465
G8	[0.467, 2.121]	[0.645, 2.683]	[1.112, 4.804]	[−2.216, 1.476]	1.294	1.664	2.958	−0.370
E4	[0.643, 2.944]	[0.883, 2.987]	[1.526, 5.931]	[−2.344, 2.061]	1.793	1.935	3.728	−0.142
E5	[1.049, 3.646]	[0.938, 3.140]	[1.986, 6.786]	[−2.091, 2.708]	2.347	2.039	4.386	0.308
E6	[0.813, 2.604]	[0.815, 2.843]	[1.629, 5.447]	[−2.030, 1.789]	1.709	1.829	3.538	−0.120
E7	[1.423, 3.935]	[1.068, 3.389]	[2.491, 7.323]	[−1.966, 2.867]	2.679	2.228	4.907	0.450
I1	[0.389, 1.832]	[0.236, 1.789]	[0.624, 3.621]	[−1.401, 1.596]	1.110	1.012	2.122	0.098
I2	[1.200, 3.683]	[1.056, 3.392]	[2.256, 7.075]	[−2.192, 2.628]	2.442	2.224	4.665	0.218
I4	[1.501, 3.910]	[0.900, 2.949]	[2.401, 6.860]	[−1.448, 3.010]	2.706	1.925	4.631	0.781
I7	[1.499, 3.820]	[1.200, 3.632]	[2.699, 7.453]	[−2.133, 2.621]	2.660	2.416	5.076	0.244

The consensus degree of the experts can be viewed by average sample gap index $\left((n(n-1))^{-1} \times \sum_{i=1}^{n}\sum_{j=1}^{n}\left(\left|t_{ij}^{p}-t_{ij}^{p-1}\right|/t_{ij}^{p}\right)\times 100\%\right)$, where n is the number of samples, p is the number of experts and t is the evaluation value in the matrix. Based on this index, the average gap of the 10 experts is 4.8%, which means the confidence level is 95.2%, indicating that these experts have a high degree of consensus.

Table 6 shows the total influence ($\tilde{s}_i+\tilde{o}_i$) and net influence ($\tilde{s}_i-\tilde{o}_i$) for all criteria. The larger $\tilde{s}_i-\tilde{o}_i$, the greater the degree to which this criterion affects other criteria. In addition, $\tilde{s}_i+\tilde{o}_i$ can indicate the total influence in the overall evaluation system to show the proportion of importance. We use $\tilde{s}_i+\tilde{o}_i$ as the horizontal axis and $\tilde{s}_i-\tilde{o}_i$ as the vertical axis to draw the cause-and-effect diagram of the criteria, as shown in Figure 2.

This approach allows policy-makers to quickly understand which criteria are the main causes and which are the effects to support the formulation of an appropriate management strategy. In Figure 2, the upper-right criteria indicate a high total influence and net influence, which are the main causes. In contrast, the lower-left criteria indicate lower total and net influences, which are the effects. Obviously, I4 is the most important affecting factor for cities to promote sustainable sports tourism and the rest are E7, I7, E5 and I2. In addition, G4, G8, S7 are the factors most affected by other criteria. The management implications derived from rough DEMATEL's analysis are discussed in Section 5.

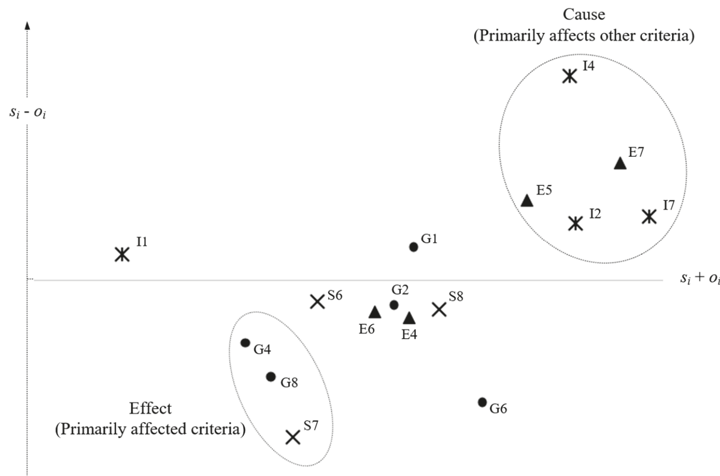

Figure 2. Cause-and-effect diagram of criteria.

5. Discussion

Sports will positively change a person's physical fitness and mental state [30,31]. The awakening of the consciousness of "sports for all" has forced major cities to invest resources to host sports events and thus shape the image of the sports cities. In order to achieve sustainable urban development, economic, social and environmental aspects are the main evaluation dimensions [8,9,24,32]. Many publications from the literature advocate the importance of institutional substantiality, so this study includes the institutional aspect as one of the evaluation dimensions to make the evaluation structure more comprehensive. By reviewing the literature and integrating the opinions of multiple experts, an evaluation system for sustainable urban tourism development was established. However, it is important to understand those criteria and to explore their mutual influential relationships. To our knowledge, these issues have not been studied and discussed.

This study proposes a two-stage MCDM decision model. Bayesian BWM is used to determine the importance weights of the criteria and rough DEMTAEL is used to identify the mutual influential relationships of the important criteria. The studies of Mohammadi and Rezaei [17] and Yang et al. [24] point out that Bayesian BWM solves the problem of integrating expert opinions for the conventional BWM and obtains a set of optimal group criteria weights. This study reduced 30 evaluation criteria to 16, which are relatively important criteria for measuring the performance of sustainable sports tourism. In terms of the Social (S) dimension, maintaining the quality of urban public order (S8) is the most important criterion in the evaluation system, with a weight of 0.223. This result echoes the findings of Gkoumas [22] and Musavengane et al. [23], where they mentioned that public order in the region affects the safety of the tourists. Some famous tourist attractions have had negative incidents, including theft, robbery, scams, traffic accidents, viral infections and racial discrimination. Before large-scale sports events are held, public security management must be strengthened and rigorous planning and control of personnel entry and exit to ensure passenger confidence in safety. In terms of the institutional (I) dimension, the development efficiency of sports tourism depends on the marketing and promotion by local governments (I7). In order to prevent urban tourism from falling into the off-season, periodic events should be organized to maintain the stability of the number of tourists. Sponsorship and support from local businesses (E5) is the most important criterion in the Economic (E) dimension. It is not difficult to understand that business sponsorship often brings more and more resources to sports activities. The sponsors and the organizers can achieve a win-win result by mutual benefit; for the participants, they can further understand the sponsor brands and experience their products. When it comes to environmental protection (G), planning for the city's mass transit system (G6) helps reduce the city's transportation carbon emissions and noise. At present, many environmental sports events have promoted zero-pollution itineraries. The measures include using electric vehicles, not using plastic materials and using recyclable containers.

Rough DEMATEL maps out the main causes and effects. The promotion of sustainable sports tourism in the cities must particularly focus on the following criteria: In conjunction with festivals in the city (I4), increasing the number of visits to the attractions in the city (E7), marketing and promotion by local governments (I7), sponsorship and support by local businesses (E5) and maintenance of the urban tourism website (I2). These criteria will affect the performance of other criteria. This result echoes the management implications of many studies, including Pouder et al. [3], Huang et al. [18], Lee and Xue [9] and Yang et al. [24]. The government must pay special attention to the performance of these five criteria. In order to allow the public to understand that the city is promoting sports tourism plans, print and online media promotion should be strengthened; sports events should be organized in conjunction with festivals. Business sponsorship also helps to increase the spread of sports ethos and makes the implementation of sports tourism plans more effective. In addition, for restrictions on plastic materials (G4), monitoring the quality of drinking water (G8) and formulating procedures for handling emergencies (S7), they require the development of other criteria to achieve high performance. The development of sports tourism in the city is a complex and difficult project: continuous simulation and review are required to make subsequent sports events more successful.

6. Conclusions

In summary, the two-stage evaluation model proposed in this study provides a complete and systematic method, providing the management implications of the development of sports tourism in the cities. This effective soft calculation method can reduce the subjectivity of management decisions. The academia has not yet studied and explored the mutual influential relationships among the criteria for sustainable sports tourism. Our model integrates several state-of-the-art methods and takes into account a variety of realistic factors, including the consideration of message uncertainty and the introduction of the concept of rough set theory.

It is well known that sports bring many benefits to people's physiology and psychology. The spirit of sustainability has brought into the sports tourism industry the purpose of accelerating the expansion of the "sports for all". This study proves the effectiveness and reliability of the proposed model. It should bring several benefits to practitioners and sports-related sectors: (i) identifying the most important and influential criteria; (ii) providing an improved basis for urban development sports tourism; (iii) helping decision-makers in the decision-making process to be more systematic.

In the future, researchers can further investigate the quantitative data of the actual assessment, making the evaluation results more accurate. Beyond that, using Bayesian BWM for cross-dimensional criteria comparison can entail more discussion.

Author Contributions: J.-J.Y. collected the data and wrote the paper. Y.-C.C. and H.-W.L. designed the research, administrated the project and verified the model. T.-I.L. co-wrote and revised the paper. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: All authors declare that they have no conflict of interests.

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International Journal of
Environmental Research and Public Health

MDPI

Article

The Attitudinal Style as a Pedagogical Model in Physical Education: Analysis of Its Effects on Initial Teacher Training

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Received: 18 March 2020; Accepted: 16 April 2020; Published: 19 April 2020

Abstract: The implementation of the pedagogical model has meant an increase in rigour and coherence in Physical Education (PE) classes. The objectives of the study were twofold; (a) to delimit the characteristics and elements that make up Attitudinal Style as a pedagogical model; (b) to analyze the perception of future teachers on the usefulness and transferability of the model in their classes. Twelve future PE teachers (seven women and five men) with an age of 20.14 ± 1.48 participated. All of them were part of the University of Burgos (Spain). A qualitative approach was used with two data collection instruments (reflective group journals and discussion group) and two categories of analysis were established: (a) usefulness in the construction of professional identity; (b) transferability of the Attitudinal Style in the school. The results showed how future PE teachers consider the model as a transcendental methodological tool in understanding and addressing PE at school. Interpersonal relationships in the classroom, student autonomy and group responsibility are highlighted as necessary aspects with high transferability to the school.

Keywords: Attitudinal Style; physical education; initial teacher training; teaching role; transferability of learning

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1. Introduction

The potential of physical education (PE) is unquestionable in encouraging student motivation towards learning and adherence to physical activity [1,2]. To this end, it is necessary to provide future teachers with tools to make the teaching and learning processes useful, meaningful, coherent and replicable. Otherwise, feelings of frustration will take hold of the students and generate demotivation towards the subject [3]. As established by Hortigüela, Pérez-Pueyo, and Fernández-Río [4], the social and cultural models of the countries directly affect the way in which PE is taught in initial teacher training, having repercussions on their way of understanding the teaching of PE.

In this sense, it is important to emphasize that the quality of future teachers will depend largely on the training they receive, which gives great importance to initial teacher training. Da Costa, McNamee, and Lacerda [5] state that the quality of training depends on variables such as the typology of the faculty, teaching methodology, skills to be developed and the design of the objectives of the subject. In fact, as commented by Pill, Penney, and Swabey [6], the subject of PE's pedagogy and sport in universities is usually approached from very different angles, which means that the learning objectives are not always clear [7]. However, it seems fundamental that students acquire different teaching approaches in the subjects linked to sport pedagogy to encourage social inclusion of the individual through the practice of physical activity [8]. Such knowledge and learning will allow future teachers to choose the most appropriate approach for their students. Under this approach of educational coherence, Karp, Scruggs, Brown, and Kelder [9] indicate that it is only possible to improve the results in the initial training of the teaching staff if teaching processes of PE are carried out under common, coherent criteria, have direct application to the classroom, and are adaptable to different contexts (recreation, free time, etc.). This would increase student motivation and connect the university and the school [10]. Changing from teacher-centred teaching to student-centred teaching [11] generates in the students an increase in motivation, responsibility, and autonomy towards work.

Within the Spanish context, in recent years a series of publications have been established that specify the most recognized pedagogical models organized into basic and emerging [12,13], and have analyzed how they have evolved from teaching styles [14–16] to pedagogical models that have been agreed upon as those that should be taught [17]. Initial teacher training in PE becomes a key element in building the professional identity of future teachers throughout their lives. In this sense, the experimentation of these pedagogical models will allow them to generate evidence of its operation and applicability in the classroom, a key aspect in their training. There are many models, although among the so-called emerging ones and those with the highest level of dissemination and production is the Attitudinal Style.

Therefore, the present article addresses two objectives: (a) to delimit the characteristics and elements that make up Attitudinal Style as a pedagogical model; (b) to analyse the perception of future teachers on the usefulness and transferability of the model in their classes.

Teaching Pedagogical Models in the Initial Training of Physical Education Teachers: The Attitudinal Style

Cañadas, Santos-Pastor, and Castejón [18] establish that in order for teachers to achieve adequate mastery of what and how to teach, it is necessary to be able to design tasks with which students can obtain real learning. In order to do so, future teachers must know and put into practice teaching techniques, styles, and strategies that make it possible to evaluate student competence [19,20].

When we go into PE, it has been proven that mastering the content that is intended to be taught and, above all, how to teach it generates a significant improvement in student learning [21–26]. In this sense, although in the last three decades the teaching of teaching styles [14,15] and their contextualization for Spain [16,27] have been the fundamental reference on how to teach [17], at present, this reference must be fundamentally linked to pedagogical models [12,13]. In this sense, there are two reasons for tackling this specific training from the knowledge of the pedagogical models: (a) firstly, because research in relation to the models has demonstrated the suitability of their application with respect to the involvement of the students and the learning generated; (b) secondly, because of the disparate perception that the traditional teaching approaches have generated among students, graduates, and teachers.

Several studies have analyzed the interests of using student-centered teaching styles and methodologies [28–30]. Zapatero's research [31] establishes that the use of student-centered methodologies and styles is less frequent than the use of methods that favour teacher control [32–36]. This has shown that after three decades of the use of teaching styles in Spain [27,32,37–40], they seem to have had little influence on adequate teacher practice. In fact, reviews of student-centred methodologies state that PE teachers [28,41,42] recognise the need to vary the methodological approach towards those that favour student involvement and motivation. However, despite the belief in the need for this methodological change, its impact is still not high in the classroom [31,33,35,43,44].

The Attitudinal Style began its journey in León (Spain) at the end of the 90s, culminating with the completion of a doctoral thesis in 2004 [45]. Considered to be one of the emerging pedagogical models [12,13], it establishes attitudes as the backbone for better learning and greater motivation towards PE. Furthermore, it proposes the use of the motor as a means (and not as an end), working simultaneously and in balance with the rest of the capacities that develop the individual in an integral manner (cognitive–intellectual, affective–motivational, interpersonal relations, and social insertion) [46,47]. Its purpose is that all students have positive experiences without exception and with inclusion [48], generating a real group that cooperates or collaborates. There are three components through which it is developed: (1) Intentional Corporal Activities, (2) Sequential Organization Towards Attitudes and (3) Final Assemblies [45,49–51]. The evolution followed by this pedagogical model, linked to the creation of the Interdisciplinary and Interdisciplinary Working Group Attitudes in 2007 (www.grupoactitudes.com) and the interaction networks established with different groups, has generated a series of reorientations and incorporations that have undoubtedly benefited the proposal. Among these, two stand out: (a) the proposal of competences through the so-called INCOBA Project (Project for the Integration of Basic Competences) [52–56], and (b) the incorporation of formative evaluation associated with self-evaluation and co-evaluation processes [56,57] through the design [58] and elaboration of new evaluation and qualification instruments [59,60].

The Attitudinal Style is a pedagogical model with a global character since it can be implemented in any curriculum content. It focuses on the learning process and the needs of the students. In fact, its applicability to any content allows its hybridization with other models [52,56]. One of the aspects that characterizes it is the innumerable amount of pedagogical and didactic material generated in these 25 years, partly collected in the bibliographical review of Tena [61] and which can be downloaded free of charge from the web (www.grupoactitudes.com) or from repositories such as https://www.researchgate.net/. Examples of its pedagogical and didactic application can be found in physical conditions [45], intentional games without elimination [56], sports such as football [62], basketball [57] or Gaelic football [63], opposing sports [64], drama [65], acrobatics [66], dance [67], shadow theatre [68], activities in the natural environment such as knots and obstacle breaking [69], and street work [51].

Therefore, the main aspects that characterize it are: (a) that the guidelines in its teaching are very clear and can be analyzed in detail in all the didactic and pedagogical publications generated in the last decades; (b) that it can be applied in diverse contexts and in any type of content; (c) that it guarantees its replicability by other teachers in diverse contexts. In relation to the latter, the research carried out at the end of the 1990s and which led to the author's doctoral thesis [45] showed that the results obtained through the Attitude Scale for Integrated Physical Education (EAEFI) strongly expressed the improvement of the attitude towards the PE of students receiving the Attitudinal Style.

After years of pedagogical and didactic production, research continued and Hortigüela, Fernández-Río, and Pérez-Pueyo [70] evaluated the effects of the prolonged use of a traditional teaching approach and the Attitudinal Style by finding that students who experienced the Attitudinal Style perceived the PE class to be significantly more useful than with the traditional approach. When the two approaches were compared in teaching football [71], the groups that experienced the Attitudinal Style developed a more task-oriented perception of the classroom climate than those who received the traditional approach. In relation to the factors implicit in physical self-concept, after having received a physical fitness teaching unit its effectiveness was demonstrated with respect to the positive influence on girls and its direct influence on their self-concept [72].

In relation to the responsibility in the assessment [73], they showed that the students who received the Attitudinal Style increased individual and group responsibility in the regulation of work during the process and the authenticity of the acquired learning linked to real life [74]. In the same vein, Hortigüela, Pérez-Pueyo, and Fernández-Río [75] demonstrated the increased level of responsibility of PE students in the assessment process.

2. Materials and Methods

2.1. Participants

Twelve future PE teachers (7 women and 5 men) with an age of 20.14 ± 1.48 participated. All of them were studying for their Primary Education Degree at the Faculty of Education of the University of Burgos (Spain). As this is a qualitative methodology, the participants were not sought to be representative of the whole. They were intentionally selected according to the criteria of voluntariness, motivation and high academic record in the degree. Specifically, they studied the subject of Physical Education and its didactics, an obligatory subject in the training of future PE teachers. The teacher of the subject was 34 years old; he was a doctor and a specialist in the implementation of pedagogical models, especially in the Attitudinal Style. This professor is one of the researchers of the study, which allowed for granting a validity to the applied design and a greater knowledge of the obtained results.

2.2. Instruments

Two different instruments were used for the collection of information. The questions that make up each of the instruments used were structured on the basis of the two categories of the study and to obtain greater specificity of the data [76]. Therefore, these instruments are based on construct validity as they are built specifically in relation to the objectives of the study.

Reflective group diaries: The main objective of the elaboration of the diaries was to reflect on the learning generated throughout the development of the subject. This diary was prepared in groups of four, and all the members of the group discussed the most relevant aspects. It is completed weekly in order to give a periodicity to the experiences of the subject. The teacher throughout the course reviewed this diary to provide constant feedback for its proper implementation. It had a semi-structured character, starting from three categories on which students had to add the information (Table 1). This allowed for two things: on the one hand, uniformity in the collection of data from all the class journals, and on the other, the freedom of each group to expand the reflective and personal information as much as they considered [77].

Table 1. Weekly information collection structure of the reflective group journals.

Weekly Information Collection Structure
1. What aspects have we dealt with this week in class (type of contents/tasks, organization of groupings, time management ...)?
2. How has the methodology of the activities influenced the construction of my professional identity (reflection on the objectives set, structure of the sessions, adaptation of the tasks to the characteristics of the students ...)?
3. What is the applicability of what we have seen in class to our professional future as teachers (transfer of the methodology to the school, usefulness of the tasks dealt with ...)?

Discussion groups: They were developed at the end of the process with 12 students who had a high grade in the course. The qualification obtained in the degree and not in the specific subject was taken into account in order to not bias the results obtained. A semi-structured script was used to collect the information (Table 2). All the participants spoke in a proportionate manner about each of the issues raised. The teacher gave the floor in order to encourage dialogue, discussion, and exchange of ideas.

Table 2. Basic script used for the final discussion group with the students.

The Script Used for the Final Discussion Group
Why do you think the subject you have studied is important?
What methodological aspects do you highlight as fundamental? Why?
What do you think the Attitudinal Style contributes in relation to other pedagogical models?
What do you think the Attitudinal Style has contributed most to your understanding of PE?
Do you think the Attitudinal Style is transferable to the school's Physical Education? Why?
What are the main benefits of this pedagogical model for children at school?
After taking the course, have you changed your perception of the EF in any way? In what?

2.3. Design and Procedure

The research responds to a retrospective design of a phenomenological nature based on the understanding of educational phenomena from the analysis of the participants' discourses [78].

The research has been structured in four distinct phases, from February to June 2019:

Phase 1. Structuring of the study and planning of the subject: The theoretical and practical classes were designed throughout the semester. The 24 theoretical classes revolved around the teaching pedagogy of the PE, focusing on knowledge of the curriculum and its adaptation to the classroom. Specifically, aspects related to methodology and evaluation were worked on in depth. In the 32 practical classes, we worked on a diversity of contents: cooperative challenges, acrobatics, judo, juggling, jumping to the combat, collective sports, alternative sports, etc. All these contents were taught through the Attitudinal Style, respecting the phases and elements that characterize it.

Phase 2. Elaboration and revision of the reflexive group diaries: The group work throughout the course elaborated these diaries. With a weekly cadence, the students collected their reflections. The teacher of the subject gave periodic feedback so that the instruments had an adequate quality and collected evaluations of the whole subject.

Phase 3. Elaboration of the discussion group: After finishing the subject, the discussion group was carried out with the students. It lasted 90 min, and from the beginning the group was told about the importance of their answers for the research. The session was recorded on video for a better recapitulation of the data after viewing. The anonymity of their answers was guaranteed. We sought to deepen the theme of the study in order to reach a reflective conversation in a relaxed atmosphere.

Phase 4. Analysis of the data by the researchers: The data from the reflective journals and the discussion group were transcribed and placed into the text analysis software Weft QDA. In addition, there was an in-depth reflection on the aims of the study, the procedure carried out, and its suitability for the objectives set.

To start the research, first, permission was obtained from the Ethics Committee of the University of the principal researcher. To this end, the protocol established at the university was followed (https://www.ubu.es/vicerrectorado-de-investigacion-y-transferencia-del-conocimiento/comision-de-bioetica). The students were clearly informed about the purposes of the research. They were encouraged to answer the questions as truthfully as possible and were assured that their answers would not affect their course grades. A formative and shared assessment was used throughout the course, which guarantees the involvement and responsibility of the students in carrying out the tasks. This implies both a constant feedback between teacher and students, and the use of the grading instruments throughout the process. This process of transparency favors the self-regulation of student tasks and the need for the veracity of their answers to justify the work done.

2.4. Data Analysis

A qualitative approach was employed to gain an in-depth understanding of future PE teachers' perceptions of Attitudinal Style. For this purpose, their experiences and reflections were studied in depth, analyzing the transferability and usefulness of this pedagogical model. The source for obtaining data was the assessments and experiences of those involved in the process. This allows us to reflect on the study phenomenon and how the interactions between the participants influence the very purposes of intervention, focusing mainly on interpretative models [79]. A triangulation was carried out between the information obtained in the data collection instruments, which was very positive as it allowed for a multidimensional analysis [80]. This triangulation was carried out among the data collection instruments used, provided that the information contributed significantly to the study categories. From this triangulation, the most significant text extracts were selected.

In order to guarantee the reliability, transferability, and credibility of the results, the most significant text extracts were coded in each of the instruments using the cross-matching patterns [81]. The researchers took an active part in the field work, reflecting throughout the process on the influence of events.

2.5. Generation of Categories and Their Categorization

Once the data from each instrument used was transcribed, it was placed into the Weft QDA computer and analysis program. Through the saturation of texts and coinciding ideas, the information was grouped into the two categories of the study: (a) utility in the construction of professional identity; (b) transferability of Attitudinal Style in the school. These categories are in relation to the objectives of the study, thus respecting the criteria of specificity and coherence that all qualitative research should have [82].

- Usefulness in the construction of professional identity: aspects related to the way in which having received the methodology of the Attitudinal Style has served them to position themselves towards the approach that they want to give to the PE, what their educational goals should be, and what factors directly influence their school treatment.
- Transferability of the Attitudinal Style in the school: This links all the information related to the way in which the Attitudinal Style can be applied in the school: contents, tasks, student motivation, organization of spaces, materials, and generation of a positive climate in the classroom.

2.6. Coding of Data Collection Instruments

Different acronyms are used to identify the text extracts with the data collection instruments from which they came from. In relation to group reflective journals, (DRG) is used. With regard to discussion groups, (GDE) is used.

3. Results

The results are structured according to the categories generated. These categories have been constructed from the different data collection instruments and the objectives of the study. In each category, the most significant text extracts obtained are presented.

3.1. Usefulness in the Construction of Professional Identity (242 Text Extracts)

We see how future PE teachers' value Attitudinal Style as a model has positioned them to approach PE in certain ways:

> *"It is usual in physical education to be told about games and diversity of activities, but the methodology used in this subject is allowing us to be aware of how important it is to control all the variables in the classroom […]. "It is very different from the physical education we have experienced as students, since in class we see how important it is to justify the teaching units we do according to the type of students we will have in the classroom, and depending on these adaptations we will achieve our objectives better"* (DRG).

> *"You realize throughout the course how physical education is the most relevant subject in the curriculum, since the treatment of the body is very much linked to children's fears, insecurities and learning. "The Attitudinal Style methodology has helped me to know what kind of PE teacher I want*

to be and how I will show my students tomorrow." "Now I always think more than once about each activity, seeing how to present it in the most motivating way possible to the students so that they can get it and learn from it" (GDE).

The results show how PE's future teachers fundamentally emphasize the Attitudinal Style in the pursuit of group success in the classroom and the empowerment of students' abilities:

"I was afraid at the beginning of the course about what I might find. In many cases at school, I felt excluded by the group [...]. In this subject, I would highlight the opposite, as we have always worked as a team and managed to get things done together." "Sometimes I thought I was incapable when David told me what we were going to do, but the methodology and the way the activities were carried out showed that we always ended up getting them." "We're seeing how the easiest thing is to make an excuse not to do an activity ... However, we are learning how important it is for all students without exception to be able to achieve, as this strengthens their self-esteem, and here the teachers are key [...]." (DRG).

"I admit that at the beginning of the course I was quite competitive and individual [...]. Now I have realized that solidarity in the group is fundamental in PE." "Many students may consider themselves incapable of starting, when this is not true [...] One of our roles has to be to break those beliefs and make them see that they can like the rest." "What's the point of achieving something if it can't be shared with your peers? Challenges, when they are a team, make more sense and that is one of the main things I take away from the subject and methodology" (GDE).

Another fundamental aspect that they have highlighted is obtaining resources about how to teach the classes and the fundamental role that PE should have in the schools:

"I used to think that a teaching unit was simply a series of games and that's it [...] Now I'm seeing that a game or task in itself is not worth anything, it has to have a meaning to allow the student to think." "There are many resources that I take with me from the subject, and that will undoubtedly be useful for me to develop in the classroom" (DRG). *"I believe that we have a very important challenge for the future, and that is to ensure that the school has a fundamental role in the schools." "We can do many projects from the school that impact on the day-to-day life of the students [...] Service-learning programs that promote health are important"* (GDE).

3.2. Attitudinal Style Transferability in School (257 text excerpts)

We can see how the students highlight the methodology received in the subject as fundamental to give rigor to PE and to what has to be taught in the subject:

"The methodology received in the subject has helped me to realize that everything has to have a reason in our classes [...] We could not expect all students to learn in the same way, and for that we as teachers have to give rigor to the subject." "We must teach many types of content in class, but the key is in how we teach them" (DRG). *"What is the point of doing many tests and sports if the whole class does not enjoy and learn from them? I am clear that the importance lies in the success of the group and in shared responsibility"* (GDE).

Students also stressed the importance of relating PE to other subjects:

"One of the fundamental things we are seeing in the subject is the importance of generating motivation in our students [...]. That motivation is born when the task you propose is a challenge for the student, and that can be related to other subjects" (DRG). *"We have seen in the units how physical education can be related to other subjects, both at the level of content and at the level of motivation or social relationship [...]." "The body is a fundamental agent of learning and must be present throughout the curriculum"* (GDE).

Finally, future PE teachers value receiving these methodologies at the university as something fundamental since they have a clear connection with the school and the extracurricular environment. In addition, they highlighted the possibility of hybridization with other approaches:

> *"This is the first time we have received a methodology with such a practical component." "David always shows us videos of students doing the things he proposes in class, and that always allows you to see the reality." "We are a little tired of receiving subjects that talk about innovation and theories where we don't see where or how they can be applied." "This methodology in physical education has many possibilities in school and outside it, since it has the personality and emotions of the students very much in mind" (DRG). "I am left with many things, but above all with the way in which we have received the classes and the constant reflection of each activity. This reflection is fundamental to have as future teachers." "This methodology is very interesting for the motivational part that it entails, and it can also be hybridized with other models, as we have seen in the didactic unit"* (GDE).

4. Discussion

The objectives of the study were twofold: (a) to delimit the characteristics and elements that compose Attitudinal Style as a pedagogical model; (b) to analyse the perception of future teachers about the utility and transferability of the model in their classes. The structural elements of the attitudinal style have been delimited, showing it as a model with a trajectory and great applicability in the area of PE. In this sense, the future teachers of PE have valued this model as ideal for the construction of their professional identity, with the social, motivational, and self-concept aspects being best valued for their transferability to the school.

The results have shown the importance that future teachers have given to the Attitudinal Style in order to position themselves as a way of understanding PE. It has helped them to reflect as professionals about the type of PE they consider necessary to teach in schools in the future. As indicated by Pérez-Pueyo and Hortiguela [83], we are in a moment in which it is necessary to be reflexive and critical about the postulates that revolve around PE, since there are too many passing fads that obviate the learning that is truly generated in the subject. We must bear in mind the teaching pillars that must structure the subject, and for this, it is necessary that from the initial teacher training we use the pedagogical models [13]. It is necessary to give coherence and consistency to the teaching processes of the PE, specifying the learning results to be achieved. This is the best way to be positively evaluated both on a curricular and social level [84].

Another one of the positive aspects that the participants have highlighted about the Attitudinal Style has been the social relationships generated throughout the course. The future teachers say they have seen how success in the achievement of tasks is more satisfactory when it is achieved in a group, totally changing the dynamics that are generated in class. Moreover, they have stressed that this fact allowed them to increase their self-concept and self-esteem. These results are in line with others [85], which reflect the social purposes that PE must have since motor experiences achieve their full meaning when they allow them to be shared with others. This positive social climate must be generated under three fundamental criteria: (a) student commitment to the task; (b) individual and group responsibility; (c) equitable distribution of work among group members [86]. If this is worked on in this way, the increase in the motivational climate of the group will be proportional to the emotional success obtained by each individual.

Another key result of this study has been the great amount of resources that students have received thanks to the Attitudinal Style. In this way, they indicate the potential that the subject has both within and outside the curriculum. Bazana, McLaren, and Kabungaidze [87] indicate that one of the main purposes of the university should be the transferability of learning to society, and for this purpose the teaching should be structured based on the intentional development of skills of a reflective and professional nature. From PE this makes even more sense, since generating adherence to the practice of physical activity and sports means a great contribution to the health of an increasingly sedentary society [88]. In addition to these physiological benefits, the pedagogical character that characterizes PE allows for a high level of psychological and mental well-being, as long as it is approached from an angle that guarantees positive motor experiences in students [89].

Future PE teachers recognize that the Attitudinal Style goes far beyond performing a series of progressions of activities in class. It allows them to ask themselves why certain content resonates with students and what the learning objectives will be, and to work seamlessly with other subjects. This last aspect is fundamental, and more so in the primary stage where the motor aspect is ideal for optimal psycho-evolutionary development and the learning of contents associated with other subjects such as mathematics [90]. In this sense, future teachers have also highlighted the possibility of hybridizing the Attitudinal Style with other pedagogical models. This fact demonstrates their methodological capacity to interrelate key aspects in the classroom that have a direct impact on student learning. A pedagogical model should never have exclusive use by PE teachers, having demonstrated how the hybridization of the same allows it to adapt to the characteristics of the context, the content, and above all, the students [91]. It is fundamental that the initial training of PE teachers be structured based on three fundamental approaches: (a) rigorous theoretical questions linked to the discipline; (b) acquisition of methodological and evaluative resources applicable to the classroom; (c) critical reflection on the role that PE should have in schools [92]. Caldeborg, Maivorsdotter, and Öhman [93] indicate that there is still much disagreement about what the school should aim to achieve. This lack of agreement arises even amongst teachers who teach the subject, with the variables of motor commitment, type of content, and methodological orientation being the main sources of disagreement. In order to reach agreement among teachers, it is necessary to base discussions on scientific evidence about the learning outcomes of PE, which will allow us to advance rigorously every day in the classroom [94]. In this way, it will be possible to establish motor interventions in the classroom that are of a high pedagogical level, are coherent, and generate true and lasting learning.

5. Conclusions

In relation to the first objective of the study, the fundamental aspects that integrate the Attitudinal Style have been reflected, highlighting the groupings, the type of activities proposed by the teacher, the active role of the teacher, and the individual and group responsibility of the student as the most outstanding. Regarding the second objective, the future physical education teachers have valued very positively the Attitudinal Style, emphasizing its rigor when planning the subject and the great amount of methodological resources it offers. The main contribution of this study has been to propose the Attitudinal Style as a pedagogical model at an international level, providing results on the experiences of future EF teachers. However, it presents some limitations since it has only focused on teachers in training. Therefore, as a future line of research, it could be applied in the permanent training of teachers, checking what perceptions experienced PE teachers show. It could also be checked whether students who have received the Attitudinal Style show different perceptions depending on the content taught in the classroom. We consider that this article may be of interest to all those professionals teaching PE, especially those who train future teachers. If we consider the methodology as the main teaching tool, the Attitudinal Style becomes a fundamental pedagogical model to guide the educational processes in PE.

Author Contributions: Conceptualization, Á.P.-P. and D.H.-A.; data curation, A.H.-G. and A.G.-G.; formal analysis, Á.P.-P. and D.H.-A; investigation, Á.P.-P. and A.H.-G.; methodology, D.H.-A. and A.G.-G.; project administration, Á.P.-P. and D.H.-A.; writing—original draft, Á.P.-P. and A.H.-G.; writing—review & editing, D.H.-A. and A.G.-G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

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Validity and Reliability of a New Inertial Device for Monitoring Range of Motion at the Pelvis during Sexual Intercourse

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Received: 10 February 2020; Accepted: 21 April 2020; Published: 22 April 2020

Abstract: To understand the physical demands of sexual intercourse, it is necessary to monitor the kinematic parameters of this activity using relatively non-invasive technology. The aims of this study are to analyze the validity and reliability of an inertial device for monitoring the range of motion at the pelvis during simulated intercourse and compare the range of motion (ROM). Twenty-six adults were monitored during intercourse using an inertial device (WIMU) and a motion capture system (gold standard) in a test that consisted of 4 sets of 20 simulated in–out cycles (IOC) in missionary and cowgirl positions. Men and women were tested separately in a laboratory setting for simulated intercourse aims. There were no differences between the WIMU and the gold standard system at fast pace ($p > 0.05$), whereas there were differences at slow pace (~2.04°; $p \leq 0.05$; $d = 0.17$). Intraclass correlation coefficients (ICCs) for the relationship between systems was very close to 1 at both paces (slow: 0.981; fast: 0.998). The test–retest reliability analysis did not show any difference between sets of measurements. In conclusion, WIMU could be considered as a valid and reliable device for IOC range of motion monitoring during sexual intercourse in missionary and cowgirl positions.

Keywords: sexual activity; posture; IOC; kinematics; WIMU

1. Introduction

Sexual activity has been recognized as an essential, integral aspect of human life [1]. When practiced safely and well, it offers health benefits and is closely linked to life expectancy [2]. Various studies have shown that sexual activity may have mental health benefits and improve cognitive functioning [3]. It may work as an anti-stress therapy by increasing levels of oxytocin [4], which inhibits the action of cortisol [5]. Sexual activity also decreases the risk of cardiovascular disease [1]. Frequent sexual activity can increase vasodilatory capacity, improve the functioning of the vascular wall of the arteries and veins and improve the efficiency with which oxygen is provided to the muscles, thus promoting cardiovascular health [6].

Sexual intercourse can be considered a physical activity since it involves musculoskeletal movement that results in energy expenditure [7]. Ainsworth et al.'s [8] compendium of physical activities lists sexual activity as having a mean intensity of 1.5 to 1.8 metabolic equivalent of tasks (METs), and a recent study concluded that healthy adults perform sexual intercourse at an intensity of 5.8 METs [9]. However, more research on different kinematic and physiological parameters during sexual intercourse is needed in order to have a better understanding of the demands of this activity [10].

Perhaps part of the reason for the lack of research on sexual intercourse is that it is an activity that involves physical intimacy with another person. In some sectors of the society, decisions about sexual intercourse may carry connotations of acceptance or rejection. The methodological difficulties associated with this type of research may also be a factor. Regardless, the variety of results obtained about the intensity and demands of the sexual intercourse in the studies [7–9] carried out to date makes it necessary to re-examine the physical demands of sexual intercourse. The use of less invasive technology, which takes into account the bioethical issues involved in this type of research, could allow genuine (not simulated in the laboratory) sexual intercourse to be monitored.

Several studies have tried to monitor the lumbar spine range of motion during sexual intercourse in different men's and women's positions [11,12] since some of the factors related to a decrease in the frequency of sexual intercourse are not only physiological but also mechanical [12]. For example, a previous study reported that the second and third most frequently quoted statements concerning the decrease in the frequency of sexual intercourse by females and males, respectively, was "difficulty with pelvic movements" [11,13]. In this regard, previous investigations on the kinematic demands of sexual intercourse concluded that positions such as the missionary elicited high lumbar spine flexion in both men and women, and therefore, it was not recommended for the flexion-intolerant patient [11,12]. As well as this, another investigation observed that the cowgirl position required intensive hip flexion range of motion, which caused prosthetic impingements [14]. As a result, this intercourse position could be potentially risky for patients with hip pathologies [14]. Hence, a biomechanical analysis of the movements and postures during sexual intercourse is considered necessary, specifically for the mentioned-above positions [11,12,14]. In addition, the ability of a system to calculate the range of motion of the lumbar spine implies its ability to detect the in–out penetration cycles (IOCs), described as the angular displacement from maximum flexion to maximum extension of the pelvic movement [12]. Gold standard motion capture (MOCAP) systems are used in this type of research, but the use of these systems is restricted to laboratory settings for technical reasons: the complexity of the installation, calibration procedures, or data analysis [15].

Therefore, at the moment, it appears that inertial measurement units (IMUs) may be a good alternative to MOCAP systems. IMUs collect 3D data (x, y, and z) using a combination of accelerometers, gyroscopes, and magnetometers [15]. In addition, some IMUs may synchronize with physiological data collected from additional sensors (e.g., heart rate, muscle activation, or muscle oxygen sensors) [16]. This allows practitioners to gain a better understanding of both the physiological and kinematic demands of sexual intercourse. Thus, the use of wearable sensors is essential when doing research in a sexual activity context. These devices are wireless, light, small, and easy to use [15]. Consequently, participants have intimacy and autonomy to perform the activity at home without the intervention of any researcher or specialist. Moreover, the multi-sensor fusion of accelerometers, gyroscopes, or magnetometers may be beneficial to successfully comprehend the participants' performance in sexual intercourse [17]. Various systems are currently available on the market for research purposes and clinical applications [15], but several improvements in data logging, data processing, and device attachment must be made before these systems can be used more widely [18].

Given the above-mentioned reasons regarding the methodological difficulties associated with this type of research, the importance of measuring range of motion during specific sexual intercourse positions (e.g., missionary and cowgirl positions) as well as the advantages of the use of wearable sensors (i.e., practically useful to monitor real situations without causing an invasion to the participants), the validity and reliability of inertial devices for their use during sexual intercourse is necessary. Only one study has investigated the application of accelerometers to sexual intercourse in order to monitor inertial parameters that may help to accurately classify sexual disorders (e.g., premature or delayed ejaculation) [19]. However, we do not know any studies that have analyzed the validity and reliability of inertial devices when used to evaluate the range of motion during sexual intercourse. Hence, the aims of this study are (1) to analyze the concurrent validity of an inertial device for monitoring range of motion at the pelvis during simulated intercourse in missionary and cowgirl positions; and (2) to analyze the test–retest reliability of an inertial device for monitoring range of motion at the pelvis during simulated intercourse in missionary and cowgirl positions.

2. Materials and Methods

2.1. Participants

Twenty-six participants (age: 23.65 ± 3.01 years old; height: 1.75 ± 0.07 m; weight: 70.75 ± 12.43 kg) took part in the study, 15 men (age: 24.2 ± 3.02 years old; height: 1.79 ± 0.06 m; weight: 77.86 ± 10.47 kg) and 11 women (age: 22.91 ± 2.94 years old; height: 1.69 ± 0.04 m; weight: 61.04 ± 7.3 kg). The sample size was calculated using G*Power software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) [20], specifying statistical power >0.85, $p < 0.05$, and medium effect size (Cohen's $d = 0.5$) for sufficient power in the study [21]. The aims and methods were explained to all participants, and any questions they had about the procedures or other aspects of the study were answered. They were told that they would be free to stop the test or leave the study at any time. They then provided fully informed consent to take part in the study. Prior to the evaluation, all participants were informed verbally and in writing of the study objectives and procedures. The procedures were previously designed according to the Declaration of Helsinki and approved by the University's Bioethics Committee.

The inclusion criteria were male or female; adults between the ages of 18 and 55 years old; previous experience of heterosexual intercourse in the positions specified in the Methods section. Any diagnosed pathology or musculoskeletal dysfunction was considered as grounds for exclusion.

2.2. Procedure

Potential participants received a dossier giving information about the objectives and protocol of the study so that they would know what was involved before attending the laboratory appointment. Men and women were tested singly in separate sessions. Potential participants who were available and interested in participating were assigned to the appropriate test session. The protocol was explained again, with a demonstration by one of the male researchers (for the men's session) and by a female collaborator (for the women's session).

To ensure that participants would be comfortable performing the required movements, folding screens were placed between the researchers and participants to prevent the researchers from seeing the movements made during the tests and thus give participants some privacy. A female collaborator was present in the laboratory throughout the women's tests, even though the researchers could not see the movements of participants. The participants performed 4 sets of 20 in–out cycles (IOCs; 2 sets at a slow pace and 2 sets at a fast pace) after 1 familiarization set to the test at each pace. Sidorkewicz and McGill [12] describe the IOC as the range of motion (degrees) between the maximum flexion and maximum extension of the movement (Figure 1). Then, the range of motion from each IOC was collected.

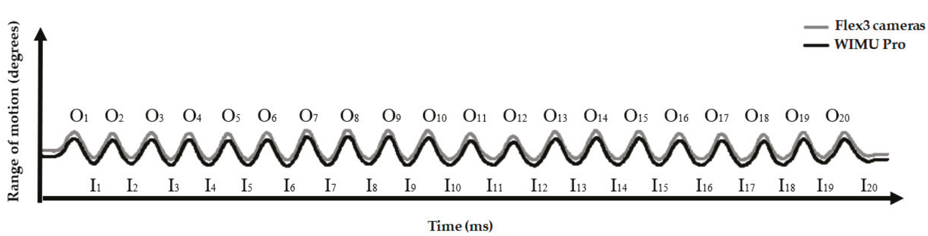
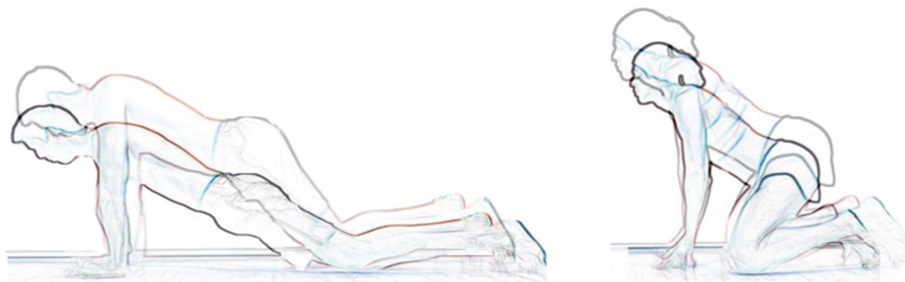


Figure 1. Description of the range of motion from twenty in–out cycles (IOCs) that were performed by one participant recorded by both systems (Flex 3 cameras and WIMU Pro) and separated by in–out phases. (I: in-phase; O: out-phase).

The participants performed the sets back-to-back with a five-second break staying in the "out" phase of the cycle. The absolute frequency of movement at both paces was controlled by the participants in accordance with their previous experience. Thus, the familiarization sets were used to allow participants to adapt themselves to the procedure. The data collected during the familiarization sets were excluded from the statistical analysis. The included sets (Sets 1 and 2 for slow and fast paces) were used to analyze concurrent validity, whereas the test–retest reliability was analyzed by following the same protocol on a different session. Men performed the test in the "missionary" posture (Figure 2a) and women in the "cowgirl" posture (Figure 2b). After the test had been completed, the recorded data were encrypted in a database.



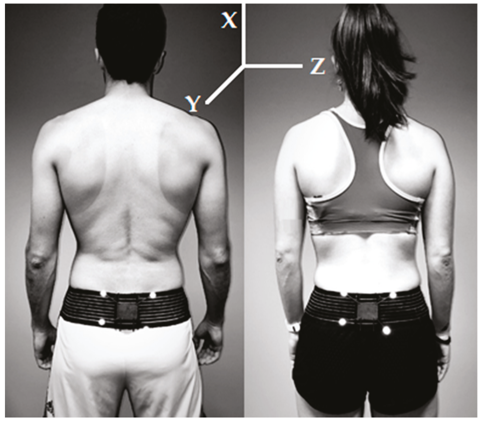
(a) (b)

Figure 2. (**a**) Missionary posture. (**b**) Cowgirl posture.

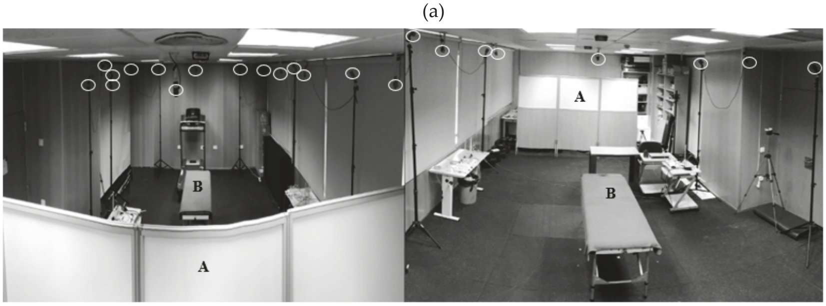
2.3. Instruments

One WIMU Pro device (RealTrack Systems, Almería, Spain) was used to record pelvic movements. This device incorporates a variety of inertial sensors, which include four 3D accelerometers and three 3D gyroscopes that collect data at a sampling frequency of 1000 Hz in addition to a 3D magnetometer and a barometer that collects data at 100 Hz. This device provides 3D accelerometry data (x, y, z) and 3D angular velocity (x, y, z), and combining these parameters enables the attitude sensor to calculate the orientation of an object with respect to a reference point. Since the movement of a rigid solid with respect to a fixed point is described by the Euler angles, a set of 3 angular coordinates appears, which provide the orientation of a reference system of mobile orthogonal axes with respect to a fixed one [22]. Thus, angular displacement could be analyzed by the Euler Z channel. The device was placed vertically in an elastic pocket (Aptonia, Lille, France) attached to the sacral area.

A MOCAP system of 16 infrared cameras (Flex 3, Optitrack, Natural Point, OR, USA) was also used (this system is considered as the gold standard) for the first and second aim of the study. This system registered the angular displacement of a rigid body created by 4 spherical markers (B & L Engineering, Tustin, CA, USA) that were placed, by the same tester, on a rigid body marker base which had 4 threaded marker posts of different lengths (Optitrack, Natural Point, OR, USA) on top of the WIMU Pro device in the sacrum area (S3 vertebrae was considered as the anatomical reference for the placement of the rigid body marker base; Figure 3a) within the testing area (Figure 3b). These 4 markers formed a rigid body from which the angular displacement on the *x*-axis was extracted at a frequency of 100 Hz using Motive software (Optitrack, Natural Point, OR, USA). This system has shown good accuracy and reliability in clinical and research applications [23] and spinal morphology testing [24].



(a)



(b)

Figure 3. (**a**) Placement of inertial device and spherical markers on the sacrum in men and women. (**b**). Back and front view of the experimental set-up, which included folding screens (A), testing area (B), and 16 optoelectronic cameras (white circles).

In the current study, each IOC was calculated by "Cycles Monitor", available on SPro software (RealTrack Systems, Almería, Spain). The "Cycles Monitor" analyzes the signal from angular displacement data. It is based on an algorithm that selects windows of samples ($N = 400$) and calculates the midpoint of that window, which is the origin of the signal. Once the origin of the signal allows the identification of both positive and negative phases, the "Cycles Monitor" detects peaks and calculates the difference between one peak and another (range of motion in degrees). Then, the range of motion between the minimum and maximum values (degrees of the in–out phases, respectively) of every IOC was obtained for each instrument

2.4. Data Synchronization from Both Instruments

The synchronization of the data from the two systems was made possible by reducing the sampling frequency of the inertial device from 1000 to 100 Hz using SPro analysis software (RealTrack Systems, Almería, Spain). First, the down-sampling procedure was followed with a low-pass filter, which only lets low-frequency data pass through. The software uses the Fast Fourier Transform to analyze the signal in the frequency domain and eliminate the data at high frequencies (more than 100 Hz). Then, the software takes 100 samples from a total of 1000 samples in a second and removes the noise from the signal. Therefore, the synchronization of the data was facilitated since the signals from both instruments were now at 100 Hz. By observation, maximum and minimum peak values of every IOC from both signals were detected. Subsequently, the time offset in milliseconds between one signal and another was calculated. Since both data sources have a constant frequency, SPro software has an "Apply time offset" option that corrects that time difference between both signals. Then, the minimum value (degrees) of the "out" phase of the first IOC of each test and the maximum value (degrees) of the "in" phase of the last IOC in the test were reviewed in order to ensure that the synchronization procedure was successful.

2.5. Statistical Analysis

Preliminary Shapiro–Wilk normality tests indicated that all variables (range of motion during IOC at Set 1, 2, 3, and 4 collected by WIMU Pro and Flex3 cameras) were normally distributed, so parametric tests were used in all subsequent analyses.

Student's *t*-test for paired samples was used to detect systematic differences between the systems (validity), and between the sets performed by a given participant (reliability). Effect sizes for between-groups effects (Cohen's *d*) were calculated using a combined standard deviation and evaluated using the following criteria, trivial: 0–0.19; small: 0.20–0.49; medium: 0.50–0.79; large: ≥0.8 [25].

The concurrent validity of the WIMU Pro device was analyzed by calculating the following statistics: the difference between the systems (systematic bias), pairwise relationships between the systems (calculated using least squares linear regression [26], standard errors of measurement (SEMs), intraclass correlation coefficients (ICC) (2,1) with 95% CIs [27], and effect sizes (to quantify the magnitude of differences).

ICCs with 95% CI were also used to evaluate the relative reliability of each system in calculating mean angular movement at slow and fast paces. Absolute reliability, defined as the degree to which repeated measurements vary within individuals, was determined using the standard error of measurement (SEM) and the coefficient of variation (expressed as % CV) [28].

The statistical power and effect size were calculated with G * Power software (v.3.1) (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) for OSX [20]. The statistical power was greater than 0.9 in all the variables analyzed with the sample size selected in the present study. The statistical analysis was carried out with IBM SPSS Statistics software version 25 (SPSS, Inc., Armonk, NY, USA), and the level of significance was set at $p \leq 0.05$.

3. Results

Table 1 shows the concurrent validity of WIMU Pro device as a method of monitoring range of motion in IOCs at slow and fast paces, relative to the gold standard Flex3 camera system. There were differences between the systems at slow paces (~2.04°, $p < 0.001$), but the effect size was very small ($d = 0.17$) and the difference between systems was lower than the standard error of the measurement (SEM = 2.34°). At fast pace, there were no significant differences between the systems (~0.24°, $p > 0.05$) and the differences were lower than the SEM (2.96°). At both paces, the ICC was very close to 1, with $p < 0.001$ (Table 1).

Table 1. Concurrent validity of WIMU Pro device relative to the MOCAP system when used to monitor range of motion during fast- and slow-paced IOCs.

	Slow Pace	**Fast Pace**
WIMU Pro (95% CI; °)	24.91 ± 10.92 * (19.91–29.27)	31.01 ± 11.96 (24.64–37.83)
Flex3 cameras (95% CI; °)	26.96 ± 12.13 (20.62–29.65)	31.26 ± 11.72 (24.56–37.01)
Systematic bias (°)	−2.04 ± 2.45	−0.25 ± 0.24
Cohen's *d*	0.17	0.02
SEM (°)	2.34	2.96
R^2 correlation	0.96 *	0.98 *
ICC (95% CI)	0.981 (0.894–0.994) *	0.998 (0.993–0.999) *

* $p < 0.001$; IOC: in-out cycle; CI: confidence interval; SEM: standard error of measurement; ICC: intraclass correlation coefficient; °: degrees.

Table 2 shows the test–retest reliability of the systems when used to monitor range of motions during IOCs at slow and fast paces. There was no systematic difference between the test and retest and the absolute differences were lower than 1.5° for both systems. The SEM obtained was 2.6°. The % CV was greater at the slow pace than the fast pace in both systems (mean: 7.72% vs. 5.28%). The ICC was very high in both systems (mean: 0.987, $p < 0.001$).

Table 2. Test–retest reliability of WIMU Pro and MOCAP system when used to monitor the range of motion during fast- and slow-paced IOCs.

Variable	WIMU Pro		Flex3 Cameras	
	Slow Pace	Fast Pace	Slow Pace	Fast Pace
Set 1 (95% CI; °)	24.69 ± 11.31 (19.91–29.27)	31.24 ± 12.37 (24.64–37.83)	26.38 ± 12.57 (21.07–31.69)	31.39 ± 12.13 (24.92–37.85)
Set 2 (95% CI; °)	25.14 ± 10.69 (20.62–29.65)	30.78 ± 11.67 (24.56–37.01)	27.54 ± 11.83 (22.54–32.54)	31.13 ± 11.42 (25.05–37.22)
Systematic bias (°)	−0.44 ± 2.73	0.45 ± 2.50	−1.16 ± 2.72	0.25 ± 2.35
Cohen's *d*	0.04	0.03	0.09	0.02
SEM (°)	2.24	3.00	2.48	2.94
CV (%)	7.15	5.47	8.29	5.09
ICC (95% CI)	0.985 (0.965–0.993) *	0.986 (0.964–0.994) *	0.989 (0.970–0.996) *	0.990 (0.973–0.997) *

* $p < 0.001$; IOC: in-out cycle; CI: confidence interval; SEM: standard error of the measurement; CV: coefficient of variation; ICC: intraclass correlation coefficient; °: degrees.

Figures 4 and 5 represent the results of the linear regression analysis at slow and fast paces, respectively. Both figures show a high positive correlation between the angular values registered by the two systems, $R^2 > 0.9$ ($p < 0.001$; Table 1).

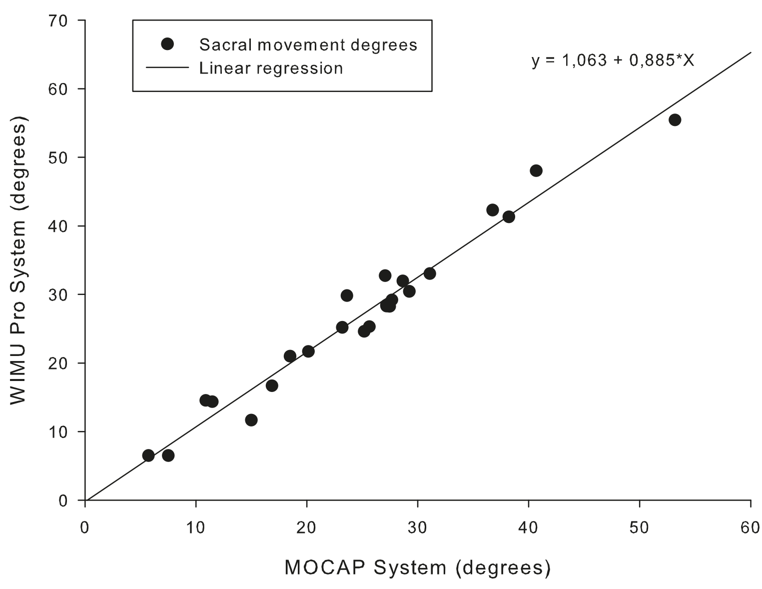


Figure 4. Correlation between systems for range of motion monitoring during slow IOCs.

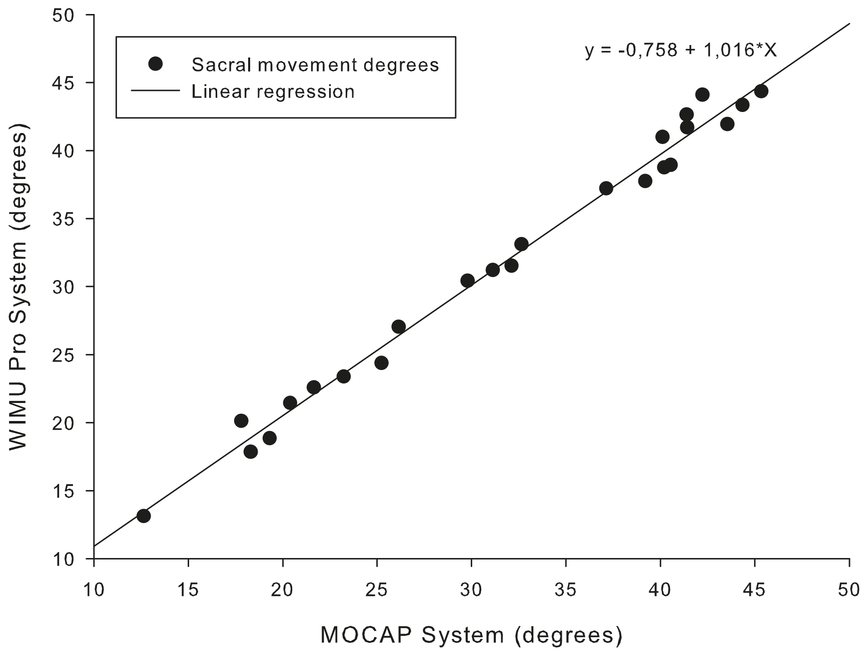


Figure 5. Correlation between systems for range of motion monitoring during fast IOCs.

4. Discussion

The aims of this study are to analyze the concurrent validity and test–retest reliability of an inertial device for monitoring range of motion at the pelvis during simulated intercourse in missionary and cowgirl positions.

The main finding was that the WIMU Pro system produced valid measurements when compared with the gold standard MOCAP system (16 Flex3 infrared cameras). In addition, the WIMU Pro showed high test–retest reliability when used to monitor the range of motion of IOCs in men and women.

The WIMU Pro device can be considered to have high concurrent validity as the difference between the systems was just 2.04°, which was lower than the SEM (2.65°). In addition, the ICC and R^2 for both paces were greater than 0.96 ($p < 0.001$). A previous analysis of the concurrent validity of WIMU Pro for the analysis of the range of motion during flexion and extension of the hip in a straight leg raise test [29] found similar results (difference = 0.5°, ICC = 0.99, and $R^2 = 0.99$), although the SEM was lower (0.05).

Other studies that have validated inertial sensors by comparing them with optical systems for capturing the range of motion in the same axis of movement (flexion–extension) found the following systematic differences in evaluations of the hip movement: 1.55° (during a hip flexion test) [30], 1.8° (during an upright posture test) [31] and 2.42° (during level walking test) [32]; in evaluations of the range of motion of the trunk during a sit-to-walk test: 0.45° [30]; in the range of motion of the lumbar spine during a standing forward flexion test: 1.82° [33], in the range of lumbar–pelvic movement during a standing forward flexion test: 3.06° [21]. The following additional statistics were reported: $R^2 = 0.78$ [21] and $R^2 = 0.82$ [34]; SEM = 2.47° [32] and SEM = 3° [31,33], and an ICC of 0.99 [35].

It was necessary to assess the test–retest reliability of the WIMU Pro device for monitoring IOCs in men and women to confirm that observed differences in the range of motion were not due to systematic errors of measurement and were not random errors caused by mechanical variation [28]. The systematic bias was less than 0.5° at both paces, and the maximum CV was 7.15% (CVs ≤ 10% are considered acceptable for analytic purposes [28]. The ICCs showed that the WIMU Pro has excellent reliability when used for IOC monitoring. Other researchers who have analyzed the reliability of gold standard technology for analyzing the range of motion of the hip [36] found an ICC of 0.92, CV of 3.6°, and SEM of 1.9°. A previous study of the reliability of the WIMU Pro device when used to measure the range of motion in hip flexion–extension [29] reported an ICC of 0.984, CV of 0.01%, and SEM of 0.31°.

The main limitation of this study is that, because analysis of the validity and reliability of a device requires control over the process of data collection, it had to be carried out under laboratory conditions. For example, the participants simulated the movement individually (not in pairs). Moreover, both IOC paces depended on the participants' experience in sexual intercourse. The test–retest reliability was analyzed with a five-second break. As this is the first study to analyze the validity and reliability of an inertial device for monitoring range of motion at the pelvis during sexual activity in men and women, the results could only be compared with previous research on the validity or reliability of similar devices testing different variables and a similar range of motion (same axis of movement) [21,29,31–36]. Further research on the validity and reliability of other devices for monitoring range of motion at the pelvis during sexual activity is needed to make it easier to compare systems. Furthermore, it would be of great interest to conduct future validation studies for the SPro software algorithms, which are the foundation of any outcome variable. Since this study collected data from young adults (~24 years old), it is suggested that future studies consider a larger sample size, which may include a wide range of ages.

5. Conclusions

This research showed that the WIMU Pro is a valid and reliable inertial device for monitoring IOC range of motion during sexual activity in missionary and cowgirl positions. The WIMU Pro could be used to analyze the kinematic parameters of specific forms of sexual activity in naturalistic contexts. However, caution should be taken when analyzing the range of motion at the pelvis in different positions of sexual intercourse.

Author Contributions: Conceptualization, J.M.O.-L., I.M.-F., and J.M.M.; methodology, J.M.O.-L. and J.M.M.; validation, J.M.O.-L., I.M.-F., and J.M.M.; formal analysis, J.M.O.-L. and J.M.M.; investigation, J.M.O.-L., I.M.-F., and J.M.M.; resources, J.M.O.-L., I.M.-F., and J.M.M.; data curation, J.M.O.-L. and J.M.M.; writing—original draft preparation, J.M.O.-L.; writing—review and editing, visualization, and project administration, J.M.O.-L., I.M.-F., and J.M.M.; visualization, J.M.O.-L., I.M.-F., and J.M.M.; supervision, J.M.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: José M. Oliva-Lozano was supported by a scholarship funded by the Spanish Ministry of Science, Innovation and Universities (FPU18/04434). Isabel Martín-Fuentes was supported by a scholarship funded by the Spanish Ministry of Science, Innovation and Universities (FPU17/03787).

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Review

The Effect of Decision Training, from a Cognitive Perspective, on Decision-Making in Volleyball: A Systematic Review and Meta-Analysis

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Received: 28 April 2020; Accepted: 20 May 2020; Published: 21 May 2020

Abstract: Over the past few decades there has been great interest in the study of cognitive processes, and specifically decision-making, from a cognitive perspective. The aim of the present study was to systematically review the scientific literature on the effect of decision training interventions/programs, from a cognitive perspective, on the decision-making of volleyball players. The systematic search was carried out in five scientific electronic databases according to PRISMA guidelines Web of Science (WOS), Pubmed (Medline), Scopus, SportDiscus and Google Scholar. A total of eight studies met the inclusion criteria. The main finding of the meta-analysis was that the use of decision-making training programs/interventions led to significant improvements in volleyball players' decision-making (Standardized mean difference = 0.94 with 95% confidence interval from 0.63 to 1.25), compared to normal active volleyball training. In addition, the heterogeneity of the interventions was low ($I^2 = 0\%$). From the results of the studies analyzed, we recommend using decisional interventions or training, both as part of normal active training or complementary to it, to improve the decision-making of the players, thus optimizing their ability to perceive and process relevant stimuli, and then generate quick and effective responses. These findings can be useful in the process of sports training.

Keywords: perceptual training; cognitive training; decision-making; volleyball

1. Introduction

The study of cognitive processes, and specifically decision-making, has been of great interest to researchers in recent years [1]. Decision-making in sport is highly relevant because it is essential for the achievement of sporting expertise [2,3].

According to Raab [4] "decision-making can be defined as the process through which athletes choose a technique appropriate for their current game situation considering their context "(p. 4). This process is complex, as it depends on athletes' abilities to detect the right information in the environment, to plan future actions, and select the most appropriate response based on the specific situation of play [5], although successful decision-making can result in achieving the ultimate goal of a given action [6].

Obtaining a detailed understanding of the decision-making process has been considered an important aim in research [7–9]. As such, numerous studies have analyzed the various processes involved when athletes try to select the correct response in sport situations [10]: anticipation [11,12], attention [13,14], experience [15,16], decision-making [17,18], memory [19,20], mental images [21,22], and perception [23,24].

Because of this, studies in sport have addressed decision-making from different perspectives. Most have tried to understand and explain the decision-making process in sport to improve performance [6]. The two fundamental perspectives for the study of these decision-making processes are: the ecological perspective [25] and the cognitive perspective [26].

The ecological perspective according to Araújo et al. [27] defines "sport as a dynamic system of constant interactions between the subject and the environment" (p. 8). During the interaction between an individual and their environment, including other individuals, athletes learn to perceive information, leading to the development of perceptual mechanisms that help capture the most important stimuli within the game context [28]. According to this perspective, during the decision-making process, the athlete collects information specific to the environment, perceiving the significant properties of the environment without mediating processes or interpretation of the information, and then issues a response [29]. Therefore, subjects in sporting situations receive information from the environment and act via a mechanism of perception-action: there is no need for the intervention of mental representations [30].

Conversely, the cognitive perspective purports that decision-making occurs prior to action, and is done based on perceptual processing that occurs prior to the processing of information [31]. From this perspective, in sports situations, athletes analyze the environment where the action unfolds to obtain the most relevant information, interpret this information using mental representations and cognitive processes, and then select an appropriate response [32]. From a cognitive perspective, the mechanism of information processing is highlighted. This mechanism is based on the athlete's cognitive strategies that occur in working memory, knowledge structures, and anticipation processes [17].

Within the cognitive perspective, two approaches have been posited for studying and understanding decision-making: the first focused on perceptual mechanisms (through the study of visual and temporal parameters) [31], and the second focused on memory-related processes [33].

Athletes' perceptual skills are hugely important in the study of decision-making considering visual and temporal parameters. According to this approach, the subject must quickly perceive and interpret information in the environment to have enough time to plan, initiate, and execute the sport skill [34]. Moreover, visual search strategies allow the athlete to extract relevant information from the environment, thus favoring an anticipated response [35]. Similarly, the approach includes temporal parameters, which are defined as the time between two processes: the selection of the stimulus (perceptive component) and the selection of the response (cognitive component). This reaction time will be influenced by previously perceived stimuli [36].

On the other hand, the performance of athletes will depend on the mental representations and cognitive processes that must be carried out between the interpretation of the stimulus and the selection of the response [37]. Therefore, the athlete's knowledge about the sport will form a basis to favor the selection of the correct answer [38,39].

It is important to pursue the improvement of decision-making given its essential role in performance [40]. The study of decision-making has demonstrated that perceptual-cognitive processes, which influence it, are trainable [41]. For this reason, research on decision-making has focused on developing and implementing interventions/training programs that improve decision-making in athletes [42].

Various programs and strategies based on the cognitive model with visual and temporal parameters have been used in decision-making training to improve athletes' abilities to detect information from the environment [43]. These training programs aim to improve athletes' understanding of information and focus on effective visual search strategies [43]. This causes the athlete to develop a series of skills that make it easier to recognize and remember different playing patterns, discriminating against irrelevant stimuli, and thus improve anticipation, decision-making, and action outcome [43]. Some of these training programs have included: viewing and simulation of game sequences [44], temporal and spatial occlusion [45], occlusion of the action sequence and feedback on accuracy [46], or manipulation of attention orientation through visual video signals [47].

Decision-making training based on memory-related processes is based on the need to provide athletes with experiences that help them be thoughtful, autonomous and able to make their own decisions [40]. In this type of training, various techniques are used, including player questioning or video feedback [4], the presentation of images or videos during training or competition to analyze tactical behavior [48], the use of mental imagery [49], and feedback [50].

Due to the need to know the effectiveness of such programs for improving decision-making in open skill sports such as volleyball, it is necessary to carry out a systematic review and a meta-analysis on this topic of research. Volleyball is a collaboration-opposition sport, with mandatory rotation of the players, in which each team is in separated courts without the possibility of invading the opposite field. Those characteristics mean that volleyball involves frequent exchanges in the ball possession and players must respond to them by making decisions with and without the ball [51]. Given that players are not allowed to catch the ball, there is a temporary deficit in the different game actions in volleyball [52], which hinders the decision-making process [53].

Considering past findings [49,54,55], we hypothesized that decision-making training programs/ interventions based on perceptual mechanisms and memory-related processes would improve the decision-making of volleyball players.

Appropriate analyses should be carried out in order to know if the hypothesis is fulfilled, and to test the magnitude of the observed effects, if any. At present, there has yet to be a meta-analysis of studies that pursue the improvement of decision-making in volleyball through intervention programs based on a cognitive perspective. The current systematic review and meta-analysis aimed to review randomized and non-randomized controlled trials to evaluate whether decision training from the cognitive approach is more effective than the typical training to improve decision making in volleyball players.

2. Methods

To perform the current review, we adopted procedures from previous review and meta-analysis studies [56,57]. Further, we considered reporting standards and guidelines from systematic review and meta-analysis protocols (PRISMA) [58].

2.1. Inclusion and Exclusion Criteria

In order to select the manuscripts included in the present study, this approach was followed: (1) the studies were based on interventions or training programs for decision-making from the cognitive perspective; (2) aspects of player decision-making were evaluated; (3) all articles pertained to volleyball; (4) English or Spanish versions of the manuscripts; (5) Articles were posted in the present century; and (6) articles were original research.

On the other hand, the following exclusion criteria were set: (1) studies from the ecological approach; (2) studies on beach volley; (3) studies focused on the improvement of declarative of procedural knowledge; (4) designs without a control group.

2.2. Search Strategy

The systematic literature search was carried out using the PRISMA guidelines [58] in Web of Science (WOS), PubMed (Medline), Scopus, SportDiscus, and Google Scholar. The search was performed considering articles published in the last 10 years. The following syntax, in two different languages (English and Spanish) was used for the search process: ("questioning" or "video-feedback" or "image viewing" or "visual search strategies" or "reflective monitoring") and ("reaction time" or "response time" or "visual function" or "anticipation" or "spatial parameters" or "temporal parameters") and ("volleyball") and ("cognitive model" or "cognitive perspective" or "perceptual mechanism" or "cognitive training" or "decision-making training" or "perceptual training") and ("decision-making") and ("intervention" or "experimental" or "quasi-experimental" or "experimental group" or "control group").

2.3. Assessment of Risk of Bias

For the assessment of risk-of-bias, we used the Evidence Project risk of bias tool, which is a simple and reliable tool to evaluate the study design (items 1–3), the bias that may affect the equivalence of the groups or the external validity of the results (items 4–6) and the potential bias from between-group differences at baseline (items 7–8) [59]. The main advantage of this tool is the applicability in both randomized and non-randomized controlled trials.

2.4. Study Selection and Data Collection

The study selection was conducted following the PRISMA guidelines. First, two of the authors (M.C.S. and C.F.-E) reviewed and manually removed duplicated articles. After that, those articles that did not fulfill the criteria were excluded. In case of disagreement between these two authors, a third author (M.P.M.A) was consulted.

Secondly, two of the authors from this manuscript extracted data from the articles included in the meta-analysis. This information was then collected and verified by a third author. The information was extracted and reported following the PICOS approach: participants, age, level of play, country and the study design (PICOS) [60].

2.5. Statistical Analysis

The Review Manager Software (RevMan, 5.3) was used for data analysis [61]. The standardized mean differences (SMD) was calculated given that different tools and units of measurement were reported in the included studies. The inverse variance test was utilized to generate SMD, which was interpreted according to the Cochrane Handbook of Systematic review as "small" when SMD < 0.4, "moderate" for values between 0.4 and 0.7, and "large" when SMD was higher than 0.7 [62]. When the outcomes were assessed using scales with opposite directions (as happened in the article by Fleddermann et al. [54] and Formenti et al. [55]), the less common was multiplied by −1 [63]. The choice between random or fixed effects models was made according to the level of inconsistency, considering the cut-off point at $I^2 > 40\%$ [64]. Given the very low inconsistence observed in the current meta-analysis ($I^2 = 0\%$), a fixed effects model was chosen.

3. Results

3.1. Study Selection

Figure 1 (PRISMA flow diagram) shows the process that has been carried out during the systematic review for the selection of the different studies. The initial search using the syntax detailed above identified 32 articles in total from the following electronic databases: WOS (7), PubMed (1), Scopus (8), SportDiscus (5) and Google Scholar (11). Three articles were eliminated because they were duplicates. Of the remaining 29 articles, 15 were eliminated because they were not related to the subject of the study, two were eliminated because the decision-making training programs/interventions were based on the ecological perspective, two were eliminated because they measured tactical knowledge and not decision-making, and two because they did not have a control group. Based on these exclusions, eight studies were included in the meta-analysis, each testing the effect of an intervention/training program based on the cognitive perspective on decision-making (Figure 1).

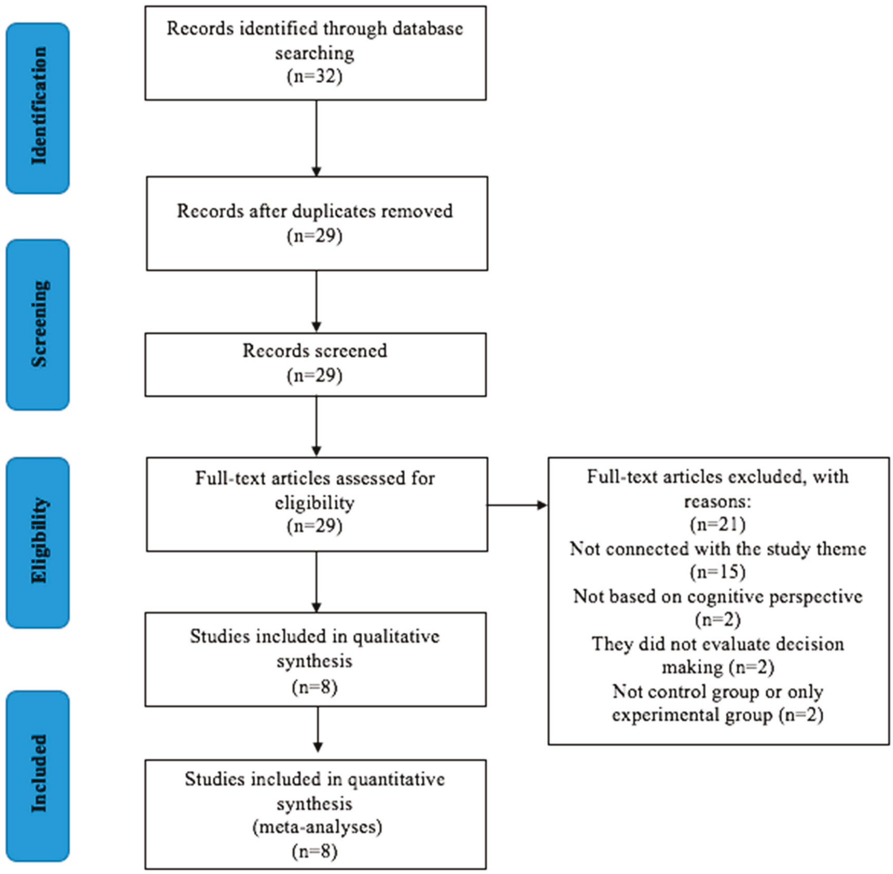

Figure 1. Summary of the search and study selection following PRISMA guidelines.

3.2. Study Characteristics

Data were extracted following the PICOS approach. In this regard, Table 1 summarizes the main characteristics of the participants (P) and the study design (S), while Table 2 shows the characteristics of the intervention (I), and the comparison (C), as well as the outcome measure (O).

Table 1. Characteristics of participants and study design.

Study	Participants	Age	Level of Play	Design	Country
Fleddermann et al., 2019 [54]	GE [1]: 22 (2 men and 20 women) GC [2]: 21 (5 men and 16 women)	Under-19	Players from 1st to 3rd division	Non-randomized controlled trial	Germany
Formenti et al., 2019 [55]	GE: 17 women GC: 17 women Only data from this group GEV [3] were used in the meta-analysis:17 women	Under-12	Regional League participants (minimum 4 years playing)	Randomized controlled trial	Italy

Table 1. *Cont.*

Fortes et al., 2020 [49]	GE: 17 men GC: 16 men	Under-17	Participants State Volleyball Championship	Randomized controlled trial	Brazil
Gil-Arias et al., 2016 [65]	GE: 4 women GC: 4 women	Under-16	Regional League Players	Non-randomized controlled trial	Spain
Lola et al., 2012 [66]	GI [4]:15 women GS [5]:15 women GC: 15 women Only data from this group GEX [6] were used in the meta-analysis:15 women	Under-12	Volleyball club players with 20 minimum workouts	Randomized controlled trial	Greece
Merzoug et al., 2017 [67]	GE: 12 men GC: 12 men	Under-17	Regional League Players	Non-randomized controlled trial	Algeria
Moreno et al., 2011 [40]	GE: 4 men GC: 4 men	Under-16	Regional League Players	Non-randomized controlled trial	Spain
Sáez-Gallego et al., 2018 [43]	GM [7]:5 women GC: 5 women Only data from this group GV [8] were used in the meta-analysis: 6 women	Under-19	Regional League Players	Non-randomized controlled trial	Spain

[1] Experimental Group, [2] Control Group, [3] Experimental Group Volleyball, [4] Implicit Group, [5] Sequential Group, [6] Explicit Group, [7] Mixed Group, [8] Video Group.

Table 2. Characteristics of intervention, comparison group and outcome measure.

Study	Intervention	Comparison	Outcome	Duration of the Intervention
Fleddermann et al., 2019 [54]	Three-dimensional multi-object training (3D-MOT)	Regular active training	Processing speed	8 weeks 16 sessions 30 min/session
Formenti et al., 2019 [55]	Perceptual training through visual search strategies	Regular active training	Cognitive performance	8 weeks 30 min/session
Fortes et al., 2020 [49]	Imaging training program	Sports ad videos	Decision making in setting	8 weeks 24 sessions 10 min/session
Gil-Arias et al., 2016 [65]	Video-feedback and questioning program	Regular active training	Decision making in attack	11 weeks 60 min/session
Lola et al., 2012 [66]	Training through videos, execution demonstrations and instructions	Regular active training	Decision making in serve	4 weeks 12 sessions 70 min/session
Merzoug et al., 2017 [67]	Perceptual simulation training	Regular active training	Decision making effectiveness	Not reported
Moreno et al., 2011 [40]	Video-feedback and questioning program	Regular active training	Quality of decision making	13 matches 13 sessions
Sáez-Gallego et al., 2018 [43]	Perceptual training through video	Regular active training	Decision making in block	4 weeks 8 sessions 20 min/session

In the different studies, there were a total of 243 participants. Of these, 97 were distributed in the experimental group, 94 in the control group, and 52 in other groups that were not included in the analysis. Six studies were conducted in youth categories from regional leagues of different countries

(Italy, Spain, Greece and Algeria), one in a Brazilian State Volleyball Championship, and one with players from the 1st, 2nd and 3rd German divisions.

Next, we summarize the following details of the decision-making training programs/interventions: duration, number of training sessions and type of decision-making training programs/interventions. In the study by Fleddermann et al. [54] the players received an 8-week training program of two workouts per week. In each session, the players had a 30-min intervention, in addition to their usual training, divided into three phases of 8 min, with a rest of 3 min between each. In this intervention, players performed perceptual-cognitive tasks via 3D-MOT, with motor tasks that were either specific (blocks, sets, attacks) or non-specific (perform jumping) to volleyball.

In the study by Formenti et al. [55] the training program lasted 8 weeks with each training session lasting 80 min. The sessions were divided into warm-up (10 min), perceptual intervention program (30 min), volleyball exercises (20–30 min), and cool down (10 min). The intervention program was divided into different stages of visual search tasks, with each task lasting 6 min.

In the study by Fortes et al. [49] the intervention program consisted of 8 weeks with a total of 24 sessions, each separated by 48 h. These sessions were held 30 min after each physical/technical training session and lasted 10 min. Players from two groups (control and experimental) participated in the same physical/technical training sessions. During the intervention, the experimental group undertook training based on the observation of images and videos of successful volleyball actions in competitive events. This training was designed to facilitate imaginative capacity. In addition, to generate emotions athletes were asked to consider an imaginary situation, in the first person, that would be close to the reality of a competition situation. During the same training sessions, the control group viewed videos related to sportswear ads (caps, T-shirts and shorts).

Gil-Arias et al. [65] involved an 11-week intervention in which a program was applied during the training sessions. The workouts lasted 120 min and were divided into two phases: firstly a 60-min technical-tactical phase, and a second phase, where the intervention program was implemented, with a 6 vs. 6 game situation lasting 60 min. During the study, all 8 players trained at the same time and competed equally, although only those in the experimental group were subjected to the program, which required players to analyze their own decisions. Specifically, players viewed videos of their performances and gave comments (video-feedback), helped by questioning. Decision-making in the attack actions performed by both groups in all competition matches during the intervention period (11 matches) were assessed.

In the study by Lola et al. [66], players experienced a four-week intervention designed to improve decision-making related to the serve in volleyball. The intervention involved a program applied 3 times a week (12 practice sessions). Each session was 70 min long with the first 30 min dedicated to training by watching volleyball videos followed by 10 min of warm-up and 30 min practicing the action considered in the video. Specifically, each player performed 20 serves to a team with six opponents, looking for free zones in the opponent's court.

Merzoug et al. [67] conducted a training program for improving various aspects of decision-making such as speed and decision accuracy. The study evaluated basic volleyball situations through simulation. The program was based on tracking multiple objects during four 3D game actions (serve, setting, blocking and defense). The program consisted of perceptual learning situations through occlusion training, play analysis and tactical volleyball discussions, as well as feedback from coaches.

In the study by Moreno et al. [40], the authors conducted an intervention comprising 13 competition matches. The program involved holding various supervisory meetings with each of the players of the experimental group between 24 and 48 h after each match. These meetings analyzed the attack situations performed by the players during these matches. During the meetings, players watched videos of their performances during the match and then offered their own analyses (video-feedback). The supervisor/mentor also asked questions (questioning) to help develop the players' reflective abilities.

Finally, Sáez-Gallego et al. [43] applied an eight-session training program over the period of one month (two weekly sessions of 20 min each). The goal was for players to use an effective visual pattern that would allow them to take advantage of highly informative areas at the time of the action. The training session consisted of four parts: (1) an attention orientation video with 16 setting sequences (eight slowed and eight normal speed); (2) training with feedback on the set direction (24 frozen sequences at the time of decision); (3) training with feedback on reaction time (24 sequences, where 12 were cut at the key time and 12 edited with light signal); and (4) random practice with 12 setting sequences without changing speed or duration.

3.3. Risk of Bias

Table 3 showed that there was a potential risk of bias due to randomization of assignment and selection. In this regard, five of the eight studies did not conduct a random assignment of participants to the intervention. As expected, there was not a random selection of participants due to the characteristics of the target population. Another potential risk of bias was the differences at baseline in two studies, which could influence the results.

Table 3. Risk of bias according to the evidence project risk of bias tool.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Moreno 2011 [40]	Y	Y	Y	N	N	Y	Y	Y
Lola 2012 [66]	Y	Y	Y	Y	N	Y	Y	Y
Gil-Arias 2016 [65]	Y	Y	Y	N	N	Y	Y	Y
Merzoug 2017 [67]	Y	Y	Y	N	N	Y	Y	N
Saez-Gallego 2018 [43]	Y	Y	Y	N	N	Y	Y	N
Formenti 2019 [55]	Y	Y	Y	Y	N	Y	Y	Y
Fleddermann 2019 [54]	Y	Y	Y	N	N	Y	?	Y
Fortes 2020 [49]	Y	Y	Y	Y	N	Y	Y	Y

1. Cohort, 2. Control or comparison group, 3. Pre-post intervention data, 4. Random assignment of participants to the intervention, 5. Random selection of participants for assessment, 6. Follow-up rate of 80% or more 7. Comparison groups equivalent on sociodemographics, 8. Comparison groups equivalent at baseline on outcome measures.

3.4. Interventions

The decision-making training programs/interventions involved video feedback and questioning, training based on image or video reproduction, three-dimensional training with multiple objects, training through visual search tasks, or training using computer simulations. The duration of the interventions varied between 4 and 13 weeks. The total number of sessions within the programs raged from 8 to 26 sessions, and the durations of these interventions/programs ranged from 10 to 60 min. The studies carried out by Formenti et al. [55] and Gil-Arias et al. [65] did not specify the number of sessions carried out in the program, but the duration of the program (8 and 11 weeks, respectively). The study by Merzoug et al. [67] did not specify either the duration of the program or the number of sessions carried out.

3.5. Outcome Measures

Figure 2 shows the effects of decision-making training programs/interventions, based on cognitive perspective, on the decision-making of volleyball players. To evaluate the decision-making of athletes in three of the articles, the Game Performance Assessment Instrument (GPAI) elaborated by Oslin, Mitchell, y Griffin [68]. Two other investigations used Superlab. The remaining three investigations each used a different instrument, these being: the program NeuroTracker^{TM} Core de CogniSens Athletics Inc. (Montreal, Canada) the reaction time test, the court performance test, and anticipation test.

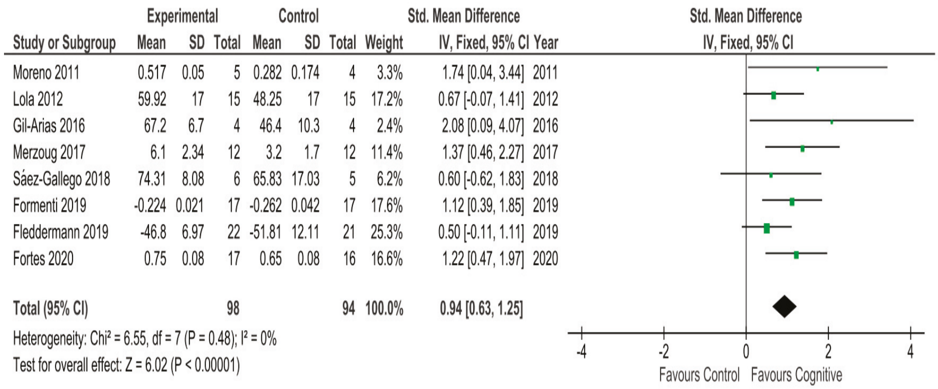

Figure 2. Meta-analysis of the effect of decision-making training programs/intervention, based on cognitive perspective, on decision making.

The meta-analysis revealed that the interventions/training programs, based on the cognitive perspective, significantly improved the decision-making of athletes in the experimental groups compared to those in the control groups in all studies (see Figure 2). These improvements would mean that players are able to better identify and process the relevant stimulus and make a more effective decision based on the perceived information. The average effect measured through the SMD was 0.94, with a 95% CI from 0.63 to 1.25. Following the proposed classification, the size of this effect was large. The level of heterogeneity was low (I^2 = 0%). Since two studies could be biased by differences at baseline [43,67], we also conducted the meta-analysis excluding them to test the potential influence of that bias. The results indicated a SMD of 0.91 with a 95% CI from 0.57 to 1.24 and I^2 = 7%. Thus, the bias caused by those differences at baseline did not influence the results of the meta-analysis.

4. Discussion

The present study aimed to systematically review the scientific literature on the effect of decision-making training programs/interventions, based on cognitive perspective, on the decision-making of volleyball players. The result of the analysis showed that training programs/interventions based on cognitive perspective led to a significant improvement in the decision-making of athletes in the experimental groups compared to those who only experienced normal active volleyball training. This significant improvement was observed in the eight studies analyzed and can be considered as a large difference based on the size of the effect (SMD of 0.94, with a 95% CI from 0.63 to 1.24 and *p*-value < 0.01). As such, the researchers of this study consider that the application of cognitive training programs based on perceptual training, or those that encourage athlete reflection (which can be used as part of usual active training or in addition to it), represent a benefit to decision-making development.

Of the articles considered in this study, four were focused on improving decision-making through memory-related processes [40,49,65,66]. These studies focused on improving decision-making through video and image viewing and by a supervisor applying questioning and video feedback. This type of training programs improved players' abilities to analyze technical-tactical actions, thus making it possible for them to make the best decision with greater efficiency [50]. Four other studies were focused on improving decision-making through visual and temporal parameters [43,54,55,67]. These studies focused on improving decision-making via perceptual and simulation training aimed at improving visual search strategies. According to Kenny and Gregory [69], this type of program helps players improve their recognition of environmental signals (e.g., by analyzing and selecting the most relevant stimulus of the opponent tactical reception system during the service [66,67]), allowing a reduction in reaction time (e.g., optimizing the interpretation of the opponent setter movements, enabling the anticipation and improving the effectiveness of the block [43]) and a better success when making decisions (e.g., identifying the optimal trajectory of the ball based on the position of the opponents and the characteristics of the opponent block [40,65]).

The durations of the decision-making training programs/interventions varied between 4 and 13 weeks, with between 8 and 26 sessions. The durations of the programs within each session ranged from 10 to 60 min. These characteristics suggest that decision-making training programs/interventions should last at least 4 weeks, with 8 training sessions, to achieve significant improvements in decision-making. Prior studies focused on improving cognitive processes via memory-related processes in youth categories have recommended that intervention programs last at least 12 sessions [70]. This is because interventions need to be sufficiently extensive to generate significant improvements in decision-making and long-term memory changes [5].

Significant improvements in decision-making due to targeted training programs are unrelated to the age or level of the participants: In all studies, regardless of age or level, significant improvements were achieved. However, it remains necessary to consider the age and level of the participants when determining the approach of the programs. Research in youth categories showed that athletes with a higher level of skill than other in the same category of play tended to have faster and more effective decision-making, which favored faster learning and adaptation [71]. Moreover, studies using the expert-novice paradigm show that experts have more knowledge of the sport and this allows them to recognize game patterns, detect relevant information and solve problems more effectively [72]. This makes achieving meaningful improvements in decision-making more complex [73] and, at the same time, more relevant [74]. However, to our knowledge, there are no studies aimed to improve the decision-making processes using decision training from a cognitive perspective in elite or amateur adult volleyball players who meet the inclusion criteria. Therefore, the results of the current systematic review and meta-analysis are limited to young athletes.

Volleyball is an open-skill sport, so the ability to make decisions is an essential component of achieving performance in the different game actions [75]. This type of sport has a complex nature, with athletes constantly making decisions in a highly dynamic and unpredictable setting [76]. This means that athletes must attend to a large number of stimuli, which they will have to perceive and then process to make a decision [77].

A review of the existing literature indicates that this is the first systematic review and meta-analysis aimed at analyzing the effects of decision-making training programs/interventions, based on the cognitive perspective, on the decision-making of volleyball players, using a valid and widely accepted methodology (PRISMA). Although the results are relevant and support the use of decision-making training programs/interventions, more interventions studies are necessary to increase the quality of evidence. Moreover, research indicates that both memory-focused programs [40,49,65,66], and those related to perceptual mechanisms [43,54,55,67] can be useful training tools to improve the perception of stimulus and the selection of the needed action, improving the decision making in sports [78]. Thus, the effectiveness of these interventions programs is largely because athletes anticipate the different actions, being able to select the best response within long-term memory, achieving optimal results in game objectives [50].

Future research should aim to compare decision-making training programs from different perspectives (cognitive and ecological) [79,80]. The present study has limitations that must be taken into account. First, three of the studies used the GPAI instrument to assess decision-making, while the other studies were conducted with other instruments. Secondly, the literature review was conducted in only two languages, Spanish and English, meaning there was a high risk that we excluded other relevant articles written in other languages. In third place, the protocol of the current systematic review and meta-analysis was not previously registered.

5. Conclusions

The use of decision-making training based on the cognitive perspective is recommended for improving the decision-making of volleyball players. These programs can be focused on improving memory-related processes via image and video viewing, feedback, or video feedback and questioning, as these methods promote cognitive participation and reflection [40]. Such programs can also lead to improvements to visual and temporal parameters via simulation training or perceptual training. These programs aim to develop the anticipation and decision-making skills of the athlete by improving visual search strategies [43]. These findings will be useful for volleyball coaches as they emphasize the usefulness of such strategies when included as part of, or complementary to, regular active volleyball training for optimizing the decisional capacity of athletes. This type of training will allow players to select and process the most relevant stimuli in the environment and generate faster and more effective responses in different situations [50].

Author Contributions: M.C.S. and M.P.M.A. conducted study design and supervision; D.C.-M. performed the data analysis; M.C.S. and C.F.-E. wrote the article interpreted the findings; A.L.P.S. and M.P.M.A. reviewed the paper. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: This article will be part of the Doctoral Thesis titled: "Study of cognitive skills in volleyball players in Spain and Brazil", by Manuel Conejero Suárez, at the University of Extremadura. This work was conducted with thanks to the Fernando Valhondo Calaff Foundation for the contribution of predoctoral contracts to young researchers.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

The Referee as an Educator: Assessment of the Quality of Referee–Players Interactions in Competitive Youth Handball

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Received: 29 April 2020; Accepted: 2 June 2020; Published: 4 June 2020

Abstract: Sport does not automatically generate educational benefits for players. For a sports field to become a child-friendly educational environment, it is essential that all actors involved in the organization of youth sport take deliberate educational measures. Among these actors are referees, who should be taken into account during the research on the educational value of sport for the youngest. The subject of the present study was handball referees, who interact with the players during matches. Assuming that the referee is an important actor in sport education and that referee–players interactions are the basic mechanism of the referee's educational influence, this study aimed to assess the quality of his or her interactions with players during handball matches for children aged 9 to 12 years. The research was conducted in a group of 25 handball referees who refereed matches of children in the region of Mazowieckie Voivodeship in Poland. The referees surveyed had current licenses issued by the Warsaw–Mazovian Handball Association. To assess the quality of referee–players interactions, the authors' direct observation tool (Referee–Players' Interaction Assessment Scoring System) was used. The educational referee–players interaction was studied in six dimensions: Positive climate, Responsiveness, Behavior management, Proficiency, Instructing, and Communicating. Data were statistically analyzed using chi-squared test, Mann–Whitney U test and exploratory factor analysis (EFA). Cronbach's alpha values were higher than 0.90 in the factors, showing adequate levels of reliability. The results of the research demonstrated that the assessment of the quality of the referee's educational influence on players was neither affected by the referees' experience nor by the outcome of the match. The quality of educational referee–players interactions in five of the six dimensions studied was assessed as average, whereas positive climate was assessed as poor (three-step scale: poor, average, good). If referees are to support coaches and parents in achieving their educational goals, the results indicate areas where they can improve. The research provided empirical evidence that could be used as a basis for the modification of previous training programs for referees developed by local and national sports associations. The referees should be trained to build a positive climate on the sport field, which consists in creating emotional ties with players (physical proximity, social conversation), expressed in an enthusiastic attitude and joy of contacts (smiling, engagement, positive affect reaction, positive comments, respectful and inclusive language, using players first names, listening to players). In addition, referees must be taught to actively monitor players' emotional, cognitive, social, and health needs, as well as to respond to the players' needs and solve problems.

Keywords: referee; referee–players interactions; handball; educational practice; pedagogical function; youth sport

1. Introduction

Many actors and institutions are involved in the organization of youth sport. Some of them undertake long-term deliberate initiatives aimed at the cognitive, moral and social development of players, using people with appropriate education (pedagogical and psychological). Others treat the educational process as an additional activity, undertaken more or less consciously. For a sports field to become a child-friendly educational environment, it is essential that all actors who organize youth sport take deliberate educational measures.

Various educational strategies for sport [1–4], normative models of the coach [5–8], parents [9–11] and teachers of physical education [12–14], and tools for the assessment of social and antisocial behavior of players [15–17] have been developed so far. Shields et al. [18] emphasized that sport does not automatically generate educational benefits for children and young people. It is the behavior and attitudes of adults during training sessions, matches, training camps, etc. that are critical to their multilateral development. Athletes often imitate the behavior of their coaches, parents, or teachers, and take their attitudes, views, norms, and values as their own [19]. Therefore, all adults involved in youth sport are teachers. These adults also include referees, who are often forgotten in studies of the educational values of youth sport.

Publications on the sports environment as a social space [20] show that sport has educational potential [21]. If properly and skillfully used by coaches, parents, or referees, it can lead to the multifaceted development of the personality of young players. It is often stressed that participation in sport improves children's self-esteem [22], helps maintain emotional balance, and encourages cooperation and leadership [23,24]. Training, sports competition, losing, and winning can be a rich source of positive personal and social experiences provided that these situations are skillfully and consciously used for educational purposes [25–31]. In addition, research results relating to the referees' use of techniques such as modelling, adopting child perspective, redirecting inappropriate behavior, building a positive climate, etc. increase the effectiveness of educational effects [32–34].

According to Andersson [35], 'referees and refereeing is an under-explored field of research (. . .) and the pedagogical function of referees is one of key importance in the co-creation of educational practices' (pp. 616–617). In scientific literature, the educational function of the referee is usually enumerated after the supervisory and ordering function. While the educational function is limited in professional sport, it should be of key importance, or at least equivalent to other functions, in youth sport. Adopting such a perspective makes the referee perceived not only as a sports competition controller but also as a teacher with adequate knowledge of pedagogy and developmental psychology [36]. A referee who is the only adult on the pitch during competitions in youth sport can make his or her attitudes and decisions an important source of stimuli shaping prosocial behavior, value systems, knowledge, and skills of young players. He or she also influences the attitudes of spectators, coaches, and other sports officials [35]. Therefore, referees should be viewed not only as ordinary technicians and evaluators of performances in competition [21], but also as teachers.

The problems of the educational function of a referee are increasingly becoming the subject of academic reflection. Among other things, this is because sports governing bodies, supporters, and parents of young players require increasingly higher qualifications and competences from referees. To date, extensive research has been undertaken on various aspects of the work of referees, including: (a) the determinants of their decisions [37–41]; (b) expected physical fitness in referees [42]; (c) identification of the key competencies of the referee [43–45]; (d) officiating communication [46–51]; and (e) athletes' expectations with regard to officiating competence [46,52,53]. Nevertheless, MacMahon et al. [43] argue that there are relatively few such studies. These authors indicated the diversity of roles that referees play in different sports as a major barrier to such studies. Different requirements have to be met by a handball referee and something else is required from a judge in gymnastics or a line umpire in tennis. In addition to controlling the actual play during a competition, sports officials must have the positive characteristics of a police officer, lawyer, judge, accountant, reporter, athlete, and diplomat.

Simply appealing to the bodies responsible for training referees to emphasize the educational dimension of refereeing is insufficient. Such demands should be thoroughly supported by empirical scientific evidence. The referees need more than just textbooks with rules of the game because nowadays they are required to show communication skills or build positive relationships with players [47]. However, as Dosseville, Laborde, and Bernier [52] argue, the interpersonal dimension of the athlete–official relationship remains largely unexplored. Lack of referees' knowledge and skills to build a positive climate during a match or to prevent negative player's behavior can contribute to children leaving the sport [1,34,54,55].

In addition, justification for undertaking this research problem is lacking a comprehensive analysis (and diagnosis) of the mutual relations between the adult actors involved in youth sport and players during sports competitions. Kirk, Macdonald, and O'Sullivan [56] stressed that sport pedagogy has three key and interlinked elements: learning, teaching, and curriculum. Over the past 20 years, research has focused mainly on the contents (curricula) and the activities of educators. Consequently, empirical research in the field of sport pedagogy did not often focus on the interactions between the educator (coach, parent, referee) and the learner (player). The presented research fits into the basic objectives of sport pedagogy, namely, to show the possibility of using sport as a means of education and to search for ways to increase the effectiveness of educational effects of sport [57].

2. Purpose

Taking into account that referees play different roles in different sports, MacMahon and Plessner [58] enumerated three types of interactions between referees and players: (i) those who interact (handball, soccer, basketball, boxing), (ii) those who react (tennis, volleyball, track and field), and (iii) those who judge (artistic gymnastics, artistic swimming, figure skating). The focus of the present study is on handball referees, who interact with players in many ways. Based on the assumption that the referee is an important actor in sport education, and that referee–players interactions are the basic mechanism of his or her educational influence, this study aimed to assess the quality of the referee's interactions with players during handball matches for children aged 9 to 12 years. The research goal formulated in this way first requires developing a referee–educator normative model and constructing a tool enabling the assessment of referee–player educational interactions. To check whether other factors influence the assessment of the quality of the referee–player interaction, the following null hypothesis was proposed: The experience of the referees and the results of the matches which they refereed do not affect the assessment of the quality of their educational interactions with the players. For the research, it was assumed that an experienced referee is one who had refereed matches for two years and more. In this study, it was assumed, that a clear advantage of one of the teams means the goal difference was ≥3. In a close match the goal difference was <3.

This assessment can help identify the strengths and weaknesses of the referee's work. The results of the research can be used to raise the referees' awareness of the importance of their relations with players on the pitch for the educational practice in sport. The conclusions from the research can also be useful for developing or modifying training programs for sports referees.

3. Materials and Methods

3.1. Participants

The research was conducted in a group of 25 handball referees who refereed matches of children aged 9 to 12 years in the region of Mazowieckie Voivodeship in Poland. The referees surveyed had current licenses issued by the Warsaw–Mazovian Handball Association. The research involved 19 men and six women. The mean age of the participants was 24.64 years (standard deviation (SD) = 9.98 years), with an age range of 17–51 years. The mean number of years of experience as a referee was 5.28 years (SD = 7.24 years, ranging from 1 to 23 years). The referees were observed as they officiated, during the period of the study, handball matches of children organized by district sports associations.

3.2. Measures

The authors' direct observation tool, Referee–Players' Interaction Assessment Scoring System (R-PIASS), was used to assess the quality of referee–players interactions. This tool has been developed based on the literature review and empirical research on the role of a referee in sport and teacher–student interactions. The basis for the development of the R-PIASS tool was the assumption that the educational function of the referee is expressed in the quality of interactions with young players. The referee–players interactions were divided into six dimensions. The description of the individual dimensions is presented in Table 1.

Table 1. Dimensions of assessing the quality of referee–players interactions.

Positive Climate	Responsiveness	Behavior Management
Means the emotional bond between the referee and players, expressing mutual interest, enthusiastic attitudes and joy of contacts	Reflects the way the referee responds to the emotional, cognitive, social, and health needs of players	Concerns methods and techniques used by the referee to prevent and redirect negative behavior of players
Proficiency	**Instructing**	**Communicating**
Is the ability to organize the game smoothly and without interruptions and prepare the referee for refereeing	Refers to the way the referee provides knowledge, interprets the rules of the game, and teaches values in sport	Is a way of verbal and non-verbal communication of decisions by the referee

3.3. Developing R-PIASS Dimensions

3.3.1. Positive Climate

The basis for a child's positive experience in sport is a good relationship with peers, the coach, and the supporting parents. The person who is not without significance for the climate during the game is the referee. For sporting competitions to become safe and educational events for children, all those involved in the organization of children's sports must work together and create a positive climate. Nowadays, it is stressed that youth sport should be free from competition and striving for winning at all costs [14]. A sports match should be a source of joy and satisfaction, because only in such an atmosphere can a child develop properly [7]. The International Charter of Physical Education, Physical Activity and Sport (UNESCO) stresses that physical education, physical activity, and sport should aim to promote stronger interpersonal ties, solidarity, mutual respect, and understanding, and to preserve the dignity of every human being. Studies suggest that with the rejection of these values, the withdrawal of children from physical activity increases [59]. Engh [60] claims that about 70% of children leave sports after the age of 13 years. These decisions result primarily from the lack of time to play, excessive pressure on competition and victory, and negative experiences in interpersonal relations [14,33,34,36,54,59]. Another reason for children's withdrawal from sports is the excessive pressure exerted by the coach [55] or parents [11].

There is a dominant conviction in the field of pedagogy that proper teacher–student interactions are the key to positive learning outcomes and instilling the prosocial behavior of the students. Pupils achieve improved results in demanding but supportive environments [61,62]. Noddings [63,64] emphasized that the school should primarily create a caring climate. If students view it as a friendly educational environment, they develop better in the physical and emotional sphere [65,66]. The same approach is currently being transferred to the area of sport [67] and has been reflected, among others, in the concept of positive youth development through sport, which postulates that youth sport should be oriented towards stimulating positive experiences based on enjoying participation in sport [1,32,33,68].

If one considers that a positive climate is one of the main determinants of sporting experience of young players, all actors involved in youth sport should take deliberate actions aimed at building a positive atmosphere of the game. The mental status of players is particularly influenced by the behavior of the referee, who can generate tension and interpersonal conflicts during the match [69].

The strategies for building a positive climate are different. Fry [67] offers the following techniques to coaches: setting the tone from day 1; provide a warm and friendly greeting to each participant; provide a positive welcome to the entire team; setting clear expectations for all to hear; helping athletes build relationships with one another; and bringing parents on board. The referee should also skillfully apply techniques of building a positive climate, e.g., give young athletes positive comments on their achievements and correct behavior [8,70]. Other characteristics of the desirable behavior of the referee are enthusiasm and smile, physical closeness, and respect for the players [71]. If the referee does not feel responsible for building a positive climate, then according to the *primum non nocere* principle, he or she should not at least build a negative one.

3.3.2. Responsiveness

The emotional support of a young athlete also requires the ability to observe and recognize his or her emotional states [37]. In the opinions of referees, the ability to interpret the players' emotions and behaviors characterizes every good referee. This aspect of the referee's work has been termed situation monitoring. It can also be called reading and interpreting player [47]. The dynamic situation on the sports field, the atmosphere of competition, and the pressure of the result make it necessary for the referee to be constantly alert. In addition to looking for opportunities to support players' emotional, cognitive, behavioral, social, and health needs [10,36], the referee should respond adequately to the situation to solve problems as quickly as possible and prevent them from escalating over time. To act effectively in this regard, the referee must take the child's perspective and help children to take the others' perspectives [36,72]. Since each match is different, referees cannot always use the same educational means, methods, and techniques. Different situations on the pitch require the use of an appropriate refereeing style and matching it with the atmosphere of the match. This is particularly important in invasion games where the referee's decisions cannot be a strict application of the letter of the law [73–75]. Refereeing requires creative and fair solutions beyond the rulebook [43].

3.3.3. Behavior Management

An important area where the referee's work can be described and evaluated (from the educational perspective) is game organization. In the literature, this area is most often described alongside the psychological aspects of decision making. Game organization is related to the actions taken by the referee before the sporting event (checking the facilities, greeting the athletes and coaches), during the event (refereeing), and after the event (writing match reports) [43]. Since the present study deals with the educational aspect of the referee's work in youth sport, the focus is on how referees prevent negative behavior and how they redirect this behavior to a socially acceptable one. In general, this means how they manage the players' behavior during the game. As Macmahon [43] notes, refereeing is more like practicing problem-solving and less like decision-making. From a pedagogical point of view, a sporting event will be conducive to education when the level of aggression and the number of unsportsmanlike behavior instances can be minimized. The referee should manage the behavior already before the match during the first contact with players or team captains. This is a good time to present the expectations concerning the players' behavior during the game and to set clear boundaries that should not be transgressed [10,43,76]. The referee's consistency in the case of behavior not meeting previous arrangements is also essential. Negative behavior is less likely when punishment is imminent [36]. The referee should use preventing officiating and preventing communication [38], and when these actions are ineffective, he or she should redirect negative behavior using appropriate methods. The study [32–34,36] demonstrated that referees knowing and using techniques of shaping pro-social behavior were much more likely to be able to effectively manage the game and strengthen the positive behavior of players compared to those who failed to use such techniques. Even brief modeling is more effective than no modeling.

3.3.4. Proficiency

In this area, the ability of the referee to organize the game smoothly and without unnecessary interruptions is important. All players should know what they are expected to do. An indicator of professionalism and proficiency in this aspect is also the proper preparation of the referee for the sporting event in terms of his or her knowledge and the necessary refereeing equipment [43].

3.3.5. Instructing

There are descriptions in the literature concerning the different dimensions of a referee's work and their refereeing styles. In addition to the 'dictator' referee and the laissez-faire style, Macmahon [43] enumerates the 'teacher' referee, who clearly and precisely justifies his or her decisions to prevent repeated violations of the rules of the game. The benefits of the development of the prosocial behavior of young athletes resulting from instruction were described by Berkowitz and Grych [10]. Instructing players consists in providing information about sports rules (helping to interpret them) and teaching the value of sport. Activities related to the clarification of existing rules of the game are particularly important in youth sport.

3.3.6. Communicating

It is worth noting that "effective communication at times can be more important than the decisions themselves" [43] (p. 81). Simmons [77] claims that even wrong decisions can be positively perceived by the players if they are communicated appropriately. Furthermore, the athletes themselves consider referees to be more honest if they explain their decisions and express them with a calm voice [49]. The referee's messages should be concise, short, and spoken slowly [47]. During a match, there is often no time to talk to the players. Referees mostly use one-way communication and therefore they are primarily responsible for the quality of communication [78]. First, the referee expresses his/her decisions with a whistle and a hand signal and then verbally. Effective communication starts with the effective method of blowing the whistle and the quality of gestures. The knowledge of using the whistle and proper signaling mechanics is fundamental for communication and education of young athletes [47]. A description of the individual dimensions and indicators of the R-PIASS tool and the way of determining their scores is shown in Table 2.

Table 2. Descriptions of dimensions.

Positive Climate			
Indicators	**Poor (1,2)**	**Average (3,4,5)**	**Good (6,7)**
Emotional connection (physical proximity, social conversation, the players seek support from the referee)	Clear physical and emotional distance between the referee and players is observed. In addition to the messages related to the game, the referee does not talk to the players.	It can be observed that the referee and the players show mutual interest, but this only applies to one team or individual players. A physical and emotional distance between the referee and the players is sometimes observed.	The referee shows great interest in all players. Physical contact and emotional closeness are observed. Their relationship is warm and supportive. The referee sometimes talks to the players about problems unrelated to the game.
Enthusiasm (smiling, engagement, positive affective reaction)	The referee does not show an enthusiastic attitude towards the players and his or her duties. They do not smile at all and do not reciprocate the positive emotions of the players.	The referee is enthusiastic and smiles, but there are moments when he or she does not do this or not to all players. The referee sometimes reciprocates the positive emotions of the players.	The referee shows enthusiastic attitudes and often smiles. He or she always reciprocates the positive emotions of the players.
Positive comments (verbal and non-verbal comments)	The referee does not give positive comments to the players at all.	The referee sometimes gives positive comments to the players or does it often, but they are apparently insincere. The referee gives positive comments to only one team or selected players.	The referee often gives positive comments to all players and they are apparently sincere and unforced.

Table 2. *Cont.*

Mutual respect (respectful and inclusive language, using players first names, calm voice listening to players)	The referee and players rarely, if ever, demonstrate respect for one another. Competitors do not recognize the authority of the referee, often questioning his or her decision.	The referee and players sometimes demonstrate respect for one another; however, these interactions are not consistently observed across time or players and it happens that the players question the referee's authority.	The referee and players consistently demonstrate respect for one another. The referee has the authority and his/her decisions are not called into question.
		Responsiveness	
Indicators	**Poor (1,2)**	**Average (3,4,5)**	**Good (6,7)**
Active monitoring of players' emotional, cognitive, social, and health needs	The referee does not monitor the players to meet their needs and does not know when the players need additional support or help.	The referee sometimes monitors the players to meet their needs and notices when they need extra support or help, but there are moments when this does not happen.	The referee constantly monitors the players to meet their needs and always notices when they need additional support or help.
Responding to the players' needs (fast meeting of the players' needs)	The referee does not respond or neglects the players' needs.	The referee sometimes responds to the players' needs, or this reaction does not apply to everyone.	The referee always responds to the educational, social, emotional, and health needs of the players.
Solving problems	The referee cannot solve a problem that goes on and on.	The referee attempts to solve the problem, but he or she does not always do it effectively.	The referee manages to solve the problems that arise, and they do not last long.
		Behavior Management	
Indicators	**Poor (1,2)**	**Average (3,4,5)**	**Good (6,7)**
Expressing expectations	The referee does not present (before the match) his or her expectations regarding the players' behavior during the game.	The referee presents his or her expectations regarding the player behavior before the match, but not understandably or does not enforce them during the game.	The referee presents clearly and understandably his or her expectations for players' behavior before the game and enforces them during the game.
Using preventative officiating	The referee does not attempt to prevent behavioral problems or does not notice the increasing negative climate.	The referee attempts to prevent behavioral problems on the pitch but does this not always or sometimes ineffectively.	The referee always attempts to prevent negative behavior and his or her actions are effective.
Redirecting negative behavior	The referee does not respond to the negative behavior of the players and it continues over time.	The referee responds to the negative behavior of the players, but his or her actions are not always effective, and the behavioral problems are extended over time.	The referee responds to the negative behavior of the players on an ongoing basis and his or her actions are effective, and the behavioral problems do not last.
		Proficiency	
Indicators	**Poor (1,2)**	**Average (3,4,5)**	**Good (6,7)**
Continuity and flow of a game	The game is not smooth and there are unnecessary interruptions.	The game seems smooth, but there are sometimes unnecessary interruptions.	The game is smooth and there are no unnecessary interruptions.
Directing players	The game is not well organized, and the players often do not know what to do.	The game is well organized, but there are situations where players do not know what to do.	The game is well organized, and the players always know what to do.
Referee preparation (knowledge and skills, referee equipment)	The referee is not prepared to referee the match, does not have the appropriate uniform and equipment, or there are often situations where he or she seeks consultation or browses game rules.	The referee is prepared to referee the match, but there are occasions when he/her consults or looks into the game rules or does not have all the referee's equipment.	The referee is well prepared to referee the match, has the appropriate uniform and full refereeing equipment.
		Instructing	
Indicators	**Poor (1,2)**	**Average (3,4,5)**	**Good (6,7)**
Communicating the game rules and teaching the value of sport (clear and precise citation of game rules, effective explanation and instruction)	The referee does not instruct players and does not provide knowledge about the game rules and the values of sport.	The referee instructs players and provides knowledge about the game rules and the values of sport, but he or she either does so rarely or in a way that is not understandable for the players.	The referee instructs players and provides knowledge of the rules of the game and the values of the sport clearly and understandably.

Table 2. *Cont.*

Communicating Decision			
Indicators	**Poor (1,2)**	**Average (3,4,5)**	**Good (6,7)**
One-way communication techniques (decision communication e.g., whistle use and signaling, strong, sharp and visible signals)	The referee is either unclear or indecisive in communicating his or her decisions or does not communicate them at all.	The referee communicates his or her decisions, but not always in a clear, decisive, or visible way.	The referee communicates his or her decisions in a visible, clear, and decisive manner.

4. Procedures

The research was approved by the Research Bioethics Commission of the Józef Piłsudski University of Physical Education in Warsaw (SKE 01–10–2020). Before starting the research, the research team met with the authorities of the Warsaw–Mazovian Handball Association (Warsaw, Poland) to present the objectives and tools used in the research and received permission to conduct it. All the referees were informed by the sporting association about the planned examinations. Immediately before the observation, all survey participants received information about the objectives of the survey, voluntary participation, and anonymity of results. Each referee had to sign a consent form to participate in the study.

The research consisted of a one-time direct observation of the referee's work during a match for children aged 9–12 years by trained observers, who were the authors of the R-PIASS tool. The relevant studies were preceded by the pilot research to test the tool and to standardize the criteria for assessing the quality of the referee's interaction with the players. The observers took part in three test observations. It was assumed that the conformity of the referee's work assessment should be above 80%. This allowed for minimization of the subjectivity of the assessments and enabled statistical analysis of research results. Each observation covered the period immediately before, during, and immediately after the match. The observation took place in a controlled manner, i.e., it consisted in regular live observation of the referee–players interactions according to a strictly defined R-PIASS key. The actions of each referee were evaluated by one observer, who noted them on the R-PIASS score sheet. Each time immediately after the observation was completed, the researcher assessed the referee's work based on score sheet notes by comparing them to the description of individual dimensions of the R-PIASS tool (Table 2). Each dimension was evaluated on a 7-step scale. How the assessment of a given dimension is determined based on indicators is illustrated in Table 3.

Table 3. The way to determine the assessment of each dimension.

Two Indicators	Three Indicators	Score	
P, P	P, P	1	POOR
P, A	P, P, A	2	
A, P	P, A, A	3	AVERAGE
A, A	A, A, A	4	
	P, A, G		
A, G	A, A, G	5	
G, A	A, G, G	6	GOOD
G, G	G, G, G	7	

Abbreviations: P = Poor; A = Average; G = Good.

5. Analytic Strategy

Basic statistical measures were used to describe the results: arithmetic means, standard deviations, and medians. The Mann–Whitney U tests were used to determine the differences in the group of referees. Cronbach's alpha coefficient was calculated to assess the consistency of the analyzed variables. Exploratory factor analysis (EFA), with principal axis factoring (PAF), was used to identify the underlying relationships between variables. The Kaiser–Meyer–Olkin measure of sampling adequacy (KMO) and the Bartlett's test of sphericity were run to check that the data were appropriate for EFA. An orthogonal Varimax rotation was used for factor rotation. For item reduction, the cut-off for significance of factor loading was set to 0.5. Calculations were performed using the PASW Statistic 18 (IBM Corp., Armonk, NY, USA).

6. Results

In the survey, 68% of the referees were characterized by refereeing experience of less than two years. About 72% of the analyzed matches took place with a clear advantage of one of the teams (a goal difference ≥3) while such matches were equally often officiated by referees of more or less experienced ($\chi^2(1) = 0.991$; $p > 0,05$). Analysis of the results of experienced referees in comparison with inexperienced referees showed no significant statistical differences between the studied groups in the quality of interaction in all six dimensions (Table 4). The test (Table 5) revealed that there were no statistical differences in the assessment of referee–players interactions during a close match or a match with the advantage of one of the teams. Therefore, the results presented in Table 6 do not take into account the division into groups.

Table 4. Differences in the assessment of the quality of referee–players interactions in all dimensions between experienced and inexperienced referees ($n = 25$).

Domains	Handball Referees					
	Inexperienced ($n = 17$)		Experienced ($n = 8$)		Mann–Whitney U Test	
	Median	$\bar{x}$ Range	Median	$\bar{x}$ Range	Z	p-Value
Positive Climate	3.00	12.18	3.00	14.75	−0.888	0.375
Responsiveness	3.00	12.47	3.00	14.13	−0.545	0.596
Behavior Management	5.00	12.85	4.50	13.31	−0.148	0.882
Proficiency	6.00	13.29	5.00	12.38	−0.299	0.765
Instructing	4.00	13.38	4.00	12.19	−0.388	0.698
Communicating	4.00	12.74	3.50	13.56	−0.271	0.786

Table 5. Differences in the assessment of the quality of referee–players interactions in three domains between a close match and a match with the advantage of one of the teams ($n = 25$).

Domains	Results of the Games					
	A Close Match ($n = 17$)		Advantage of One of the Teams ($n = 8$)		Mann–Whitney U Test	
	Median	$\bar{x}$ Range	Median	$\bar{x}$ Range	Z	p-Value
Positive Climate	3.00	9.00	3.00	9.00	0.00	1.00
Responsiveness	3.00	10.57	3.00	7.90	−1.11	0.265
Behavior Management	5.00	8.21	4.50	9.55	−0.549	0.583
Proficiency	6.00	9.14	5.00	8.90	−0.103	0.918
Instructing	4.00	7.79	4.00	9.85	−0.853	0.393
Communicating	4.00	9.29	3.50	8.80	−0.207	0.836

Table 6. Means (± standard deviation (SD)), median, and range values of the ratings of quality of referee–players interactions for individual dimensions observed in handball referees (n = 25).

Dimension	Mean (SD)	Median	Range
Positive Climate	2.8 (1.0)	3.0	1–6
Responsiveness	3.4 (1.2)	3.0	2–6
Behavior Management	4.7 (1.5)	5.0	1–7
Proficiency	5.0 (1.5)	5.0	2–7
Instructing	4.5 (1.6)	4.0	2–7
Communicating	3.9 (1.4)	4.0	2–7

Means and standard deviations for all examined dimensions are reported in Table 6. Positive Climate was rated as poor ($\overline{x}$ = 2.8; SD = 1.00). The quality of the referee–players interaction in this dimension was rated worse than the others. It is worth noting that almost half of the referees (48%) were rated as average ($\overline{x}$ = 3.0), and one referee was rated as good. The Responsiveness dimension was assessed on an average level. The quality of interactions of six referees with players (24%) was assessed as poor in this dimension and two (8%) were rated good. Two more dimensions: Behavior management ($\overline{x}$ = 4.7; SD = 1.5) and Proficiency ($\overline{x}$ = 5.0; SD = 1.5) were rated as average. The second was rated the highest of all dimensions. Nearly half of the referees surveyed received good scores in this respect. The quality of referee–players interactions was also assessed at a medium level in the dimensions of Instructing ($\overline{x}$ = 4.5; SD = 1.6) and Communicating ($\overline{x}$ = 3.9; SD = 1.4).

The value of Cronbach's alpha of 0.92 obtained from the analyses indicates a high similarity of the assessments taken into account in the study. The lowest values of correlation with the overall result were found for the Positive climate (0.463). Other ratings correlated much more strongly with the total scale, with the coefficients ranging from 0.776 (Responsiveness) to 0.894 (Behavior management).

Factor analysis was made for six variables. The KMO measure was at an acceptable level (0.786) and Bartlett's sphericity test was also significant ($p < 0.001$), indicating the validity of the factor analysis. In the initial phase of factor analysis, one eigenvalue was ≥1, thus meeting the Kaiser criterion when determining the number of factors. However, no clear and easy in interpretation structure was obtained for the one-factor solution, explaining only 71.753% of the variance (Table 7). Therefore, with a small number of variables included in the analysis, the number of factors in the second approach was determined using Cattell's criterion (scree plot) and the percentage of explained variance (>0.8). In this solution, two factors were identified, as described below.

Table 7. Results of factor analysis after Varimax rotation: values represent factor loadings for the assessments.

Variable	Factor 1
Positive Climate	0.573
Responsiveness	0.851
Behavior Management	0.930
Proficiency	0.878
Instructing	0.895
Communicating	0.903
Eigenvalue	4.305
Explained variance	71.753%

Table 8 shows the factor loadings after Varimax rotation using a significant factor criterion of 0.5. The choice of cut-off depended on the ease of interpretation. The results of the exploratory factor analysis (EFA), including two factors (Table 8), showed that first factor created variables: Behavior Management, Proficiency, and Instructing with quite high factor loadings (>0.903), Responsiveness (0.637) and Communicating (0.614), however, two assessments contributed equally to the loadings of Factors 1 and 2. Responsiveness and Communicating were complex variables. The second factor contained only a variable Positive climate. This indicates, similarly to the results of the analysis of Cronbach's alpha, a slightly different character of this variable compared to other assessments. In the case of the Communicating and Responsiveness variables, the simple structure criterion was not met, with this variable showing quite high (>0.595) factor loadings for two isolated factors.

Table 8. Results of factor analysis after Varimax rotation (two-factor solution): values represent factor loadings for the assessments.

Variable	Factor 1	Factor 2
Positive Climate		0.950
Responsiveness	0.637	0.595
Behavior Management	0.903	
Proficiency	0.940	
Instructing	0.919	
Communicating	0.686	0.614
Eigenvalue	4.305	0.908
Explained variance	71.753%	15.134%

The majority of variables represented high communality estimates (>0.848); slightly lower values were observed for Sensitivity (0.760). The two-factor solution explained about 87% of the total variance.

7. Discussion

In the field of pedagogy, it is believed that proper referee–player interactions are the key to shaping the pro-social behavior and the multilateral development of young players. Kids achieve improved results in supportive environments. The task of building the right game climate also applies to the referee. The present research assumes that the educational function of a referee in youth sport is primarily to build positive relations with young players. The main aim of the research was to assess the quality of referee–players interactions during handball matches of children aged 9–12 years.

The exploratory factor analysis was made to examine the structure and interrelationships of the variables. Factor extraction starts with a model with one common factor [79]. The single-factor structure that contained all dimensions explained 71% of the variance. Results of the EFA suggests that the R-PIASS items are unidimensional. Only Positive climate variable loadings of Factor 1 at a lower level (0.573) but according to Hair et al. [80] loadings ±0.50 or greater can be considered as practically significant. Although in the social sciences, where information is very often less precise, it is not uncommon to consider a solution that accounts for 60% of the total variance as satisfactory [79,80], it was also decided to examine the two-factor structure. Then Factor 1 included five variables, apart from Positive climate. This can be easily explained. According to MacMahon et al. [43], managing players' behavior consists of three components: (1) game organization (i.e., logistical arrangements of officiating event, preparation of a game); (2) decision-making appropriate for the game context; and (3) decision communication. In the tool used in our study, we also decided to include the Instructing component, because it fits the natural variability of the observed referee–players interactions. In this way we wanted to point out that the educational dimension of the referee's work is also focused on providing information about game rules and teaching the value of sport. The study confirmed that Positive climate is a separate factor. This factor also includes Communicating (0.614) and Responsiveness (0.595). These variables were spread across two factors. This phenomenon (cross-loading) is probably due to the fact that both the content and the way of communicating the decision are crucial. The referee's warm and calm voice contributes at the same time to building a positive climate on the pitch and a better understanding of the information he provides. The cross-loading of the Responsiveness variable can be explained by referring to Pianta et al. [71] who believe that an important element of emotional support and building a positive climate is the sensitivity to the child's needs and the ability to accept his or her perspective. Other studies have shown that failure to take into account the needs of the child results in reduced learning outcomes [81]. It follows that the lack of ability to accept a child's perspective reduces the chance of his or her development. The presence of the Responsiveness variable in Factor 1 can be explained by referring to a study by MacMahon et al. [43]. These authors emphasized that game management is a very capacious concept, which consists not only of managing the behavior of players, but also of analyzing the context of the event. The context determines both the steering style and how to react to players' behavior. Reading and interpreting a player is essential for effective game management. Therefore, the Responsiveness dimension is also in Factor 1.

Considering the phenomenon of cross-loading in a two-factor structure, the fact that traditionally at least two or three variables must load on a factor to give a meaningful interpretation [82], and ease of interpretation, it was decided to adopt a one-factor structure.

7.1. Hypotheses Verification

The studies by MacMahon et al. [83], Simmons [53], and Dosseville, Laborde, Garncerzyk [37] indicate that a referee's experience has a significant effect on his or her performance. The more experience a referee has, the better the quality and relevance of his or her decisions are. Usually, the players are very quick to know which referee they are dealing with. An inexperienced referee makes mistakes more often, gets nervous, panics, and imposes greater penalties while trying to stamp their authority. Young and inexperienced referees are at a disadvantage because in the opinion of the players they do not have qualities that the players value in referees. The players also declared that they would prefer that an inexperienced referee not officiate their matches [53]. The results of the research showed that, in terms of the educational function of the referee, greater experience did not translate into higher quality ratings of his or her interaction with players. There are two possible causes of this pattern: (1) The inexperienced (often young) referee is still full of enthusiasm, which is positively received by children, whereby such a referee can make up for the lack of experience with his or her enthusiasm; and (2) the lack of differences in ratings may be due to the fact that more experienced referees usually officiate the matches of older players and higher leagues. In youth sport, and certainly in adult sport, the educational function is less important, because the accuracy of decisions becomes the most important. A referee may be less open to the educational needs of a young athlete because of the habits he or she developed through officiating the matches played by older players. The lack of differences in the evaluation of the educational function of a referee between less and more experienced referees was also observed in studies of soccer referees [84]. The null hypothesis also assumed no differences in the referee's assessment between close matches or matches with the advantage of one of the teams. This assumption was due to the fact that a close match could have caused more emotions of players and greater pressure on the referee. Therefore, the referee could have been more focused on controlling compliance with the rules of the game and less on the educational function. The results of the statistical analyses indicated that there were no grounds to reject the null hypothesis and therefore the result of the matches did not affect the assessment of the quality of their interactions with the players.

7.2. Positive Climate

The educational function of the referee requires that the match be a positive experience for the child. The results of the research show that the referees do not cope with this task. The quality of their interaction with the players in terms of building a positive climate has been assessed as poor. This was the lowest rated dimension. Referring this result to the description of this dimension (Table 2), an emotional distance between the referee and the players was observed during the matches and they were not interested in each other. The referees were sometimes in physical proximity to the players, but this was often not the case. Furthermore, they rarely smiled and were not enthusiastic about their duties and players. They did not talk to players about problems not related to the game (social conversation) and very rarely gave positive comments. Low ratings in this dimension do not prove that the referees do not work well. These results show that if referees are to support coaches and parents in achieving their educational goals, there is a space where they can improve. Similar conclusions from the research conducted among football referees were presented by Firek, Płoszaj, and Czechowski [84]. The results of the research by Fry and Gano-Overway [85] indicate that the athletes who experienced a caring climate in the sport environment had more joy from effort and were more committed. As a result, they gave up sport less frequently [86–91]. According to Anderson [35] and Fenoglio and Taylor [6], building a positive climate requires taking a different perspective on sport. In order to support the educational experience of the players, the referee should be less focused on competition and more on growth, enjoyment, and an inclusive engagement. This is particularly important due to the existing trend of children leaving sports, especially up to the age of 13 years [1]. The reason for this is excessive pressure from parents and coaches, lack of joy of exercising, pressure to win and compete, and negative experiences in sports relations [34,54,55].

7.3. Responsivness

The Responsiveness dimension was assessed as average, which in the context of the referee's educational role means that the referees sometimes monitored the players for their needs for additional support although it happened that they did not do this. The referees noticed and responded to the needs of the players, but not to everyone. They did not always manage to solve problems and, consequently, it was extended over time. To respond to the needs of children, they must first be recognized. The ability to monitor players' behavior and diagnose their needs is often considered a key skill of a referee. Cunningam [46] argues that sensitivity to the needs of players, understanding their motives and intentions, helps the referee to be more flexible, to better adapt to the context of the match, and to choose the refereeing strategy. At the same time, Cunningam adds that this skill is most difficult to teach. The referees themselves also admit that reading body language, applying active listening, and empathetic communication are necessary to guide the behavior of players [51]. The ability to anticipate players' intentions and read their emotional states is one of the basic requirements for good refereeing [52,92,93].

7.4. Behavior Management and Proficiency

Two more dimensions: Behavior management ($\overline{x}$ = 4.7; SD = 1.5) and Proficiency ($\overline{x}$ = 5.0; SD = 1.5) were rated as average. The latter was the highest rated of all dimensions of the educational function of a referee. Of the referee surveyed, almost half received a good grade. This means that the referees are able to organize the game well and are well prepared to fulfil their duties. However, there are situations where there are unnecessary interruptions in the game and sometimes players do not know what to do. On the other hand, there were situations in Behavior management where the referees did not communicate their expectations to the players concerning players' behavior during the game, or the rules they presented were not consistently enforced. The average quality level of the referee–players interaction in the Behavior management dimension means that referees sometimes monitored the players' behavior in an attempt to prevent misbehaviors, but there have been periods without proactive actions on their part. It also happened that they tried to redirect negative behavior, but their strategies and techniques were not always effective, or the athletes solved disputes themselves. Episodes of inappropriate behavior could be observed during the matches, but they were short and limited to a small number of players. Similar results were obtained in studies on the quality of referee–players interaction during soccer matches [84]. The difference was that the soccer referees were rated higher in their ability to organize the game smoothly and without unnecessary interruptions. Simmons research [50] shows that only a small group of elite soccer referees use a wide range of techniques to 'sell decisions' and 'minimize disruption to the game'. Raising the level of knowledge and skills of referees in this field is important for them to be able to overcome social tensions and negative behavior of athletes [94], rather than being the source of such problems [69,95]. Behavior management is also associated with the ability to manage game time. If the game is smooth, the referees express their readiness to communicate with the players, have the appropriate uniforms, then the players treat the referee with more respect and authority [48,53].

7.5. Instructing and Communicating

The study also evaluated the dimensions of Instructing ($\overline{x}$ = 4.5; SD = 1.6) and Communicating ($\overline{x}$ = 3.9; SD = 1.4) at a medium level. This means that if the situation required such measures, the referees clearly communicated the game rules and/or the values of sport. However, there were situations when they did not do this, or the athletes did not understand their instructions. Usually, the referees clearly signaled their decisions, but sometimes and/or some of them did so indistinctly or indecisively. From the standpoint of the athlete, a competent referee is one who gives explanations and instructions [46,48,49,52,96,97]. A study by Simmons [49] showed that when a referee communicates and appropriately explains his or her decisions (i.e., uses a calm but firm voice) the players perceive them as fairer. Such an attitude fosters building the referee's authority, which is important from an educational point of view. A sports field can become a safe place for a child if the referee is a person the child trusts in every aspect of his or her work. Our research showed that referees communicate their decisions at a medium level. Therefore, this is another area where they can improve. Referees should communicate their decisions in a more noticeable and precise way because not all of them did this or they did this not always.

8. Conclusions

The studies of referees usually concern their place and role in professional sport. Few studies have examined their activities during competitions in youth sport. Inexperienced referees usually learn their profession and become proficient in sports for the youngest. It is therefore important to be aware that the child has specific emotional, social, cognitive, and health needs. The task of the referee is to diagnose and meet these needs. This approach is the essence of modern sport education aimed at providing a child with the positive experience that fosters their multifaceted development. A different role of a referee is evident in professional sport, where the main goal is to apply the laws of the game in a uniform and consistent way [98]. Therefore, it can be emphasized that what is good and expected in professional sport should not be automatically transferred by referees to youth sport. Some referees make the right decisions but do not support the educational process. There are also referees who may be wrong, but their attitudes and behavior on the pitch are a source of positive experiences for the players. It is also important that the referee should be aware of his or her shortcomings and areas where they can improve. This diagnosis allows them to take concrete actions to develop refereeing competences.

The sport environment is aware of the need for the education of professional referees who, together with coaches and parents, form a coherent educational system. The research provided empirical evidence that could be used as a basis for the modification of previous training programs for referees developed by local and national sports associations.

One of the purposes of the research was to develop a normative model of a referee–pedagogue who, through the appropriate quality of interactions with players, builds a positive, safe, and caring climate conducive to the multilateral development of the child and makes the sport a source of positive experiences. Thanks to this model, expressed in the R-PIASS tool, the referee can find out the behaviors required for the performance the educational function. The R-PIASS tool shows the educational role of the referee in many dimensions.

The tool allowed for the evaluation of the referee's work and its comparison to the assumed model. The results can be a source of information for individual referees and bodies responsible for training referees about the directions in which training programs should be modified. Undertaking such scientific research makes referees realize that their behaviour is significant for the emotional, social, and cognitive development of children. Taking into account the lowest-rated dimensions of referee–player interactions, the direct conclusions of the study are as follows:

- Referees' training programs should include information about the emotional, social, and cognitive needs of children at various stages of their development;
- Referees should be made aware that they are an important link in the process of education through sport and that, together with the coach and parents of young athletes, they should build a caring climate on the handball court so that the sport can be a source of positive experiences for children, especially before the age of 13 (during this period, most children leave sports);
- Referees should be trained in building a positive climate, which consists in creating emotional ties with players (physical proximity, social conversation), expressed in an enthusiastic attitude and joy of contacts (smiling, engagement, positive affect reaction, positive comments, respectful and inclusive language, using players first names, listening to players). In addition, referees must be taught to actively monitor players' emotional, cognitive, social, and health needs, as well as to respond to the players' needs and solve problems.

The results of the research showed differences in the quality of referee–players educational interactions in soccer [71] and handball. Therefore, the referees of other team sports should also be analyzed to see if the quality of the referee's educational activities depends on the type of team sport. The results of the examination did not show that the refereeing experience and the final result of the match affected the quality of referee–players educational interactions in soccer [71] and handball. This result should be confirmed based on a larger study group and in other team sports. Results also showed that referees focus more on controlling the rules of the game than on taking educational measures. It should be examined whether there is such a tendency in other team sports as well.

Author Contributions: Conceptualization, K.P., W.F., and M.C.; methodology, K.P., W.F., and M.C.; investigation, K.P., W.F., and M.C.; resources, K.P., W.F., and M.C.; writing—original draft preparation, K.P. and W.F.; Writing—review and editing, K.P. and W.F.; funding acquisition, W.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Józef Piłsudski University of Physical Education in Warsaw, Socio-Humanistic School of Physical Culture Research.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Contribution of Motivational Climates and Social Competence in Physical Education on Overall Physical Activity: A Self-Determination Theory Approach with a Creative Physical Education Twist

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Received: 25 June 2020; Accepted: 5 August 2020; Published: 13 August 2020

Abstract: Using a cross-sectional study design, we tested a structural equation model of hypothesized relationships among a group of variables: motivational climate in physical education (PE), students' social competence in PE, out of-school physical activity (PA) motivation, PA intention and their moderate-to-vigorous PA (MVPA). Based on the self-reports of 363 fourth to sixth grade elementary school students (172 girls, 191 boys), the model revealed that the task-involving motivational climate in PE was linked to higher MVPA via cooperation in PE, and also via extrinsic motivation and PA intention. Ego-involving motivational climate was related to higher extrinsic motivation and amotivation, further to higher PA intention and, finally, to higher MVPA. Task-involving motivational climate was positively linked to students' social competence markers of cooperation and empathy, and negatively to disruptiveness. Ego-involving motivational climate was positively related to disruptiveness and impulsivity, the markers of low social competence. The study showed that the motivational climate and co-operational aspect of social competence both played significant roles in students' PA motivation, PA intention and MVPA. A pedagogical model that brings the learning of social competence relevant skills to the fore is creative physical education (CPE). Analysis of CPE is provided which highlights teaching behaviors which contribute to the students' MVPA through motivational climates, co-operation, PA motivation and PA intention.

Keywords: prosocial behavior; antisocial behavior; primary school; structural equation model

1. Introduction

Physical activity (PA) is an important factor in human health and well-being, and the physical and mental health advantages of regular PA have been extensively documented [1]. Although the benefits of being physically active are well known, a significant number of youth in many countries do not achieve the recommended amounts of PA [2] In Finland, objective measurements indicate that only 34% of elementary school students (9–15 yrs) attain the Finnish recommendations [3] of having at least 60 min of moderate-to-vigorous physical activity (MVPA) on a daily basis.

In school physical education (PE), children's self-competence perceptions, such as perceived physical competence, have been found to affect their physical performance and behavior [4] and to be one of the most relevant contributors to PA during adolescence [5,6]. However, due to the socially constructed nature of self-competence and the PE context, which often involves interactions with peers, it is vital to understand the social aspect of perceived competence and its role in participants' PA motivation and PA. In addition, a variety of psychosocial outcomes are related to individuals' social competence, such as quality of life [7], psychological well-being [8,9], loneliness and social anxiety [10]. Some empirical studies have shown the positive relationship between social competence and sport/PA participation [11–15]. However, the role of social competence in primary school PE as part of the PA pattern warrants further exploration.

Social Competence and Its Potential Impact on Overall Physical Activity

Social competence is a comprehensive concept including cognitive, emotional-motivational and behavioral aspects that children need for social adaption [16,17]. This study recognized the bi-dimensional nature of social competence [18] and conceptually positioned children's social competence as consisting of two key aspects relevant to children's social adaptation, namely prosocial behavior and lower levels of antisocial behavior [10,19,20]. Prosocial behavior refers to voluntary, socially positive behaviors benefitting others and positive peer interaction, such as comforting, helping and cooperation [21]. The other dimension of social competence is the absence of antisocial behaviors that are typically socially maladaptive and undesirable, such as impulsive and disruptive behavior [8]. In this article, we understand, like many other researchers [4] that socially competent children should exhibit cooperation and empathy and inhibit antisocial behaviors. For others, however, only prosocial behavior can be seen, indicating social competence [7] that actually falls under the umbrella concept of social functioning, together with distinct but negatively interrelated antisocial behavior [22].

In order to verify social aspects of motivation and its effects on behavior, Stump et al. [17] recommend using a bottom-up approach in terms of self-determination theory (SDT). SDT is a meta-theory involving several sub-theories which assume that human behavior consists of interaction between an individual's environment, satisfaction of his/her needs and the level of motivational regulation [23]. It specifies three major kinds of motivational regulation on a continuum—intrinsic, extrinsic and amotivation—which vary according to the levels of self-determination, offering a continuum between more self-determined forms of motivation and more controlling forms of motivation.

The highest level of self-determination on this continuum is intrinsic motivation (enactment of an activity for its own sake, because the activity is enjoyable and interesting) [24]. At the other end of the continuum is amotivation (a lack of motivation or intention to participate) offering the lowest level of self-determination. Between these two on the continuum are four extrinsic forms of motivation, each having an instrumental effect on activity. Integrated regulation (assimilating the regulation of exercise into personal goals) and identified regulation (the outcomes of the behavior are highly valued) are both considered autonomous forms of extrinsic motivation. Introjected regulation (avoiding internal pressures or feelings of guilt) and external regulation (the activity is done because of external factors, such as rewards, constraints or fear of punishment) formulate controlling forms of extrinsic motivation. Evidence from motivation regulation studies on children and adolescents has typically revealed that autonomous motivation is positively associated with leisure-time PA [25,26], whereas controlled forms of motivation will undermine these outcomes. As an exception, Jaakkola, Washington, and Ylipiipari [27] found also a positive path from extrinsic motivation to self-reported PA of high-school students.

According to Vallerand [28], the possible positive effects of contextual factors on autonomous motivation are achieved through the satisfaction of psychological needs. The more positively contextual factors contribute to the satisfaction of the three innate needs—need for competence (need to achieve desired outcomes and to feel effective in one's efforts), need for autonomy (need to self-organize one's behavior and to achieve concordance between the activity and one's integrated sense of self) and need for relatedness (need to feel connected to and accepted by significant others)—the more that autonomous types of behavior are likely to occur, which in turn, may result in positive psychosocial functioning [24].

In SDT-based studies, it is unclear which of the three psychological needs (competence, autonomy, relatedness) contributes the most to PA motivation [29]. In some SDT-based studies, social competence has been a focus, but in these studies it has been conceptualized as a social-contextual factor using only one facet (cooperation) of social competence [30,31]. Junttila et al. [27] highlighted social competence's contributory role as it is readily identifiable and can be influenced by other social agents in social contexts, while Stump et al. [17] suggested that socially competent individuals could satisfy all three psychological needs within the context of social interaction.

In this study, the satisfaction of the innate psychological need for competence, normally conceptualized in SDT as physical competence, was approached instead using a conceptualization of social competence. This is a novel way of approaching the need for competence in PE, although PE has been seen as significant in the acquisition of values and competences relevant to students' personal and socio-emotional development [32]. Other researchers have explored social competence in areas associated with PA: Lemonia et al. [33] found social skills (quick temperedness, disruptiveness, cooperating skills and empathy) to contribute to the prediction of perceived quality of life for recreational dancers and trainees; Gråsten et al. [12] found an individual level association between social competence and moderate to vigorous PA; Su et al. [9] indicated that the relationship between physical exercise and children's general well-being was partially mediated by social competence; however, none employed an SDT perspective in their studies.

In addition, while the hypothesized association between innate needs, motivational regulations and PA intention have been verified theoretically via empirical studies involving secondary school PE students [24,34,35] or PA [36], far less is known about these relations in elementary school children [37,38].

Conceptualization of contextual factors in this study was realized via both task-involving and ego-involving motivational climates [39], which represent individuals' perceptions of the stress afforded by social agents (such as teachers) on developing or demonstrating competence. Task-involving motivational climate represents hard work, co-operation, personal development and effort, whereas ego-involving motivational climate represents competition, comparisons with others, success based on ability and reward/punishment for success and failure [39,40].

Students' perceptions of a task-involving motivational climate during PE have been found to be positively connected to psychological needs of competence, relatedness and autonomy [40], and to enhance self-determined motivation in PE [41]. The findings associated with an ego-involving motivational supportive climate have been shown to be linked with lower relatedness and self-determined motivation, and with higher amotivation [42,43]. Jaakkola et al. [27] indicated the positive path from the task-involving motivational climate via perceived competence and intrinsic motivation to high-school students' self-reported PA but they also found that there is not always a positive link between ego-involving motivational climates and reduced self-reported PA.

The most proximal contributor of PA in this study is PA intention, which is considered a summary motivation to accomplishing a behavior [44]. In SDT-based PE studies, students' autonomous motivation has been positively associated with intention of future PA participation [34,45] however due to mixed findings in the case of introjected regulation and amotivation, further research is needed [46]. Based on empirical findings [47,48], there is a significant positive link between intentions and future behavioral engagements, such as in PA. McEachan, Conner, Taylor and Lawton [49] approximated that intentions explain 33% of variability in PA behavior.

This study leans on the cross-contextual postulation that students' perceptions of their psychological environment (i.e., motivational climate in PE) will contribute to their adoption of moderate to vigorous PA (MVPA) [42] via their social competence and PA motivation. As a consequence, we drew on self-determination theory [24] together with Vallerand's [28] comprehensive model of motivation to investigate the relationship between student's perceived motivational climates in PE, social competence in PE, out-of-school PA motivation, overall PA intention and their MVPA. Based on the aforementioned theoretical justifications, we hypothesized that social competence will explain the interconnection between contextual factors (i.e., motivational climate), PA motivation, PA intention and MVPA.

2. Materials and Methods

Participants were 363 (172 girls, 191 boys) elementary school children, aged between 10 and 12 years (M = 11.20 ± 0.78 years), and recruited from two public schools located in the same city in central Finland. In 2011, after receiving approval from local education authorities, all fourth- to sixth-grade children (*N* = 382) in these schools, representing a total of 5% of elementary school children in the region, were invited to participate via direct contact with the school principals. Participation was voluntary for these students, who returned signed written assents with guardian consents. No extra credit or any other benefits were rewarded for participation and withdrawal from the study was possible at any time without consequence.

Within two weeks, students in one of the schools completed electronic questionnaires via the SPSS® MrInterview™ software (IBM, Armonk, New York, NY, USA) in their computer class under the supervision of their PE teacher who had no access to the responses. Due to challenges accessing computer class facilities for implementing measurements across the requisite two-week period, data collection in the other school was conducted using paper-and-pencil questionnaires under the supervision of the primary investigator (PI; first author). Teachers implementing the computer-based data collection were collectively instructed by the PI so that timing and other practices related to the administration of the questionnaires were equivalent for participants. As in the other school, any misunderstandings related to completing the questionnaires were not reported by teachers. Thus, despite the slight difference in data collection protocols, in both schools, students' information was collected through a similar process based on the same instructions and ethical principles, guaranteeing anonymity and confidentiality.

2.1. Measures

2.1.1. Motivational Climate

Perception of motivational climate in PE was measured using the Motivational Climate in PE Scale (MCPES) [22], which consists of two subscales representing task- and ego-involving motivational climates. The individual item stem used in the measure was "In my PE class ...". Both task-supportive (e.g., "It is important for students to try their best in PE lessons") and ego-supportive (e.g., "It is important for students to succeed above others in PE lessons") motivational climate dimensions consisted of four items with acceptable internal consistency, measured using Cronbach alphas (Table 1). Responses were indicated on a five-point Likert-scale ranging from strongly disagree (1) to strongly agree (5). Soini et al. [22] have demonstrated acceptable construct validity and internal consistency of the MCPES sub-scales among Finnish students.

Table 1. Correlations, Cronbach alphas (α), means (M) and standard deviations (SD) of the study variables.

	1	2	3	4	5	6	7	8	9	10	α	M	SD
1 Task-involving motivational climate	–										0.77	4.29	0.64
2 Ego-involving motivational climate	−0.02	–									0.82	2.76	0.98
3 Cooperation	0.40 *	−0.10	–								0.74	3.18	0.45
4 Empathy	0.34	−0.14	0.66 ***	–							0.65	3.32	0.48
5 Disruptiveness	−0.19 *	0.33 ***	−0.19	−0.32 ***	–						0.79	1.44	0.50
6 Impulsivity	−0.10	0.29 **	−0.21	−0.25	0.54 ***	–					0.74	1.78	0.55
7 Intrinsic motivation	0.50 ***	0.07	0.52 *	0.42 ***	−0.12	−0.12	–				0.92	3.80	0.74
8 Extrinsic motivation	0.36	0.19 **	0.44 *	0.32	−0.01	−0.05	0.77 ***	–			0.89	3.55	0.72
9 Amotivation	−0.08 *	0.24 *	−0.21 ***	−0.13	0.23 *	−19 *	−0.14 ***	0.07 ***	–		0.69	2.29	0.90
10 PA intention	0.36 ***	0.01	0.27	0.15	−0.05	−0.07	0.36	0.35 ***	−0.20 **	–	0.77	4.74	0.59
11 MVPA	0.21	0.03	0.29 **	0.14	−0.07	−0.13	0.30 *	0.26 ***	−0.17 *	0.30 ***	0.83	5.53	1.50

Note *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

2.1.2. Social Competence

Perceptions of social competence were measured using the Multisource Assessment of Children's Social Competence Scale (MASCS) that has been designed to fit the Finnish elementary school context, and validated [10], and consequently widely used [8,50,51] in Finland. The questionnaire administered in this study had a common stem for each item: "Using the scale below, circle the number that best describes you in PE classes." The scale consisted of 15 items measuring four dimensions of social competence. The dimensions were cooperation (e.g., "I participate effectively in group activities") and empathy (e.g.,"I am sensitive to the feelings of others") for prosocial behavior, whereas impulsivity (e.g., "I have a short fuse") and disruptiveness (e.g., "I argue and quarrel with peers") were for antisocial behavior. Items were rated on a 4-point scale ranging from never (1) to very frequently (4). Impulsivity and disruptiveness scores were reversed. Mean scores of cooperation, empathy, impulsivity and disruptiveness were calculated and used as social competence scores for each student. Internal consistency of the social competence scale was acceptable based on Cronbach's alphas (Table 1).

2.1.3. PA Motivation

Students' self-determined PA motivation during leisure-time was assessed with the Finnish version of the Sport Motivation Scale (SMS) [52], which was modified for the leisure PA context. The instrument has 7 subscales, comprising three types of intrinsic motivation (IM to accomplish things, IM to know and IM to experience stimulation), three forms of extrinsic motivation (identified, introjected and external regulation) and amotivation. Each dimension consists of four items. The scale had the individual item stem "I'm currently participating in leisure PA, because . . . ?". The students rated the reasons for their current participation in PA activities outside the school context on a 5-point Likert scale ranging from (1) describes me very poorly, to (5) describes me very well. Subscale scores were calculated for each subscale by summing a total of 12 items for intrinsic motivation and 12 for external regulation, and four for amotivation. Internal consistency of the self-determination scale was acceptable with appropriate Cronbach's alphas (Table 1). Further, Jaakkola, Liukkonen, Ommundsen and Laakso [53] reported adequate psychometric properties for the Finnish version of the SMS.

2.1.4. PA Intention

Student intention related to their future engagement in sport was quantified using the three items: "I will try to play sports during the school year"; "I plan on playing sports this school year"; and "I intend to play sports this school year" [45]. The students rated these items on a 5-point Likert scale ranging from (1) fully disagree, to (5) fully agree. The mean score of three items represented students' PA intention and demonstrated acceptable internal consistency (Table 1).

2.1.5. MVPA

The Health Behavior in School-aged Children Research Protocol was used to assess elementary school students' overall MVPA [54]. The stem was: "In the next two questions physical activity means all activities which raise your heart rate or momentarily get you out of breath, for example, doing exercise, playing with your friends, going to school, or in school PE. Sport also includes, for example, jogging, intensive walking, roller skating, cycling, dancing, skating, skiing, soccer, basketball, and Finnish baseball." The scale consisted of two items: "Think about a typical week for you. On how many days did you exercise for at least 60 min during which you got out of breath?" and "Think about the last 7 days. On how many days did you exercise for at least 60 min during which you got out of breath?", that students rated using an 8-point response scale (0–7 days of the week). The mean score of the two items represented children's total MVPA scores indicating acceptable internal consistency (Table 1).

2.2. Statistical Analyses

First to be examined were normal distribution, outliers and missing values of the data. Modifications due to normality or outliers were not required [55]. In total, 3.3% of values for individual items were found missing. A few missing values occurred because some children did not provide fully completed questionnaires. Little's MCAR test (χ^2 = 4100.326, df = 4203, p = 0.869) indicated that the missing values were completely random (MCAR) [33].

Next to be determined were correlation coefficients, Cronbach alphas, means and standard deviations for each variable. In order to test the factor structures of the scales, confirmatory factor analyses were conducted. A path model was implemented to test the associations between task- and ego-involving motivational climates, cooperation, empathy, disruptiveness, impulsivity, intrinsic motivation, extrinsic motivation, amotivation, PA intention and MVPA. The covariance effects of gender, school, grade, class and teacher were also analyzed.

The chi-square test (χ^2) was applied as a test of the model's overall goodness-of-fit. A non-significant difference between observed frequency distribution and theoretical distribution demonstrates an acceptable fit to the data. To determine the suitability of the model, the standardized root mean square residual (SRMR), the root mean square error of approximation (RMSEA), the comparative fit index (CFI) and the Tucker–Lewis index (TLI) were also examined [56]. A value less than 0.06 for SRMR is generally considered as a good model fit and a value of 0.08 or less for the RMSEA indicates a reasonable error of approximate fit [57]. For the CFI and TLI indices, values greater than 0.95 are indicative of an excellent model fit [57]. The proportions of variance were examined using squared multiple correlations (R^2). The missing value analysis was analyzed using SPSS Version 22.0 (IBM, Armonk, NY, USA) and the path model was conducted using Mplus Version 7.11 (Statmodel, Los Angeles, CA, USA) [58].

3. Results

As shown in Table 1, the mean scores indicated that children's perceptions of the task-involving motivational climate, PA intention and MVPA scored relatively highly. In turn, the perceptions of the ego-involving motivational climate, cooperation, empathy, intrinsic motivation and extrinsic motivation were moderate. In addition, the perceptions of disruptiveness, impulsivity and amotivation could be considered as low. The correlations showed that the associations between variables ranged from low negative to strong positive (−32 to 0.77). The strongest positive correlations were found between intrinsic motivation/extrinsic motivation and prosocial behavior variables. The strongest negative association was detected between empathy and disruptiveness.

Confirmatory factors analyses were implemented to test factor structures of the scales. All scales were found to have satisfactory fit indices: Motivational Climate in PE Scale (MCPES) (χ^2 (26) = 51.53, $p = 0.002$, CFI = 0.96, TLI = 0.95, RMSEA = 0.051, CI 90% (0.03, 0.07), SRMR = 0.042), Social Competence Scale (MASCS) (χ^2 (84) = 168.78, $p < 0.001$, CFI = 0.94, TLI = 0.92, RMSEA = 0.052, CI 90% (0.04, 0.06), SRMR = 0.053), Sport Motivation Scale (SMS) (χ^2 (203) = 413.80, $p < 0.001$, CFI = 0.91, TLI = 0.90, RMSEA = 0.057, CI 90% (0.5, 0.07), SRMR = 0.067), and PA intention and MVPA scale (χ^2 (4) = 4.30, $p = 0.367$, CFI = 1.00, TLI = 0.99, RMSEA = 0.014, CI 90% (0.00, 0.08), SRMR = 0.025). Based on this, the subscales provided reliable results for the path model development.

In order to test the associations between task- and ego-involving motivational climates, cooperation, empathy, disruptiveness, impulsivity, intrinsic motivation, extrinsic motivation, amotivation, PA intention and MVPA, a path model was constructed. This theorized model had all possible paths specified. The first step was to run the theorized model for the purpose of seeing which paths were not significant. Second, this model was configured by removing the non-significant paths. The model revealed an excellent model fit for the data (χ^2 (1) = 1.171, $p = 0.279$, CFI = 1.00, TLI = 0.98, RMSEA = 0.023, CI 90% (0.00, 0.15), SRMR = 0.006).

The final model showed positive direct paths from the task-involving motivational climate to cooperation, empathy, intrinsic motivation, extrinsic motivation and PA intention, in addition to a negative direct path to disruptiveness (Figure 1). Ego-involving motivational climate was in turn positively linked with disruptiveness, impulsivity, intrinsic motivation, extrinsic motivation and amotivation. In the next column, cooperation was positively related to intrinsic motivation, extrinsic motivation and MVPA, whereas the relationship with amotivation was negative. Additionally, positive associations between the prosocial behaviors of cooperation and empathy and the antisocial behaviors of disruptiveness and impulsivity, as well as a negative relation between empathy and disruptiveness, were detected. Next, intrinsic motivation had a significant link with extrinsic motivation, and extrinsic motivation with amotivation. Amotivation was negatively related to PA intention that was further positively linked with MVPA. The model explained 18 to 41% of variance of the study variables, with the highest squared multiple correlation (R^2) found in the intrinsic motivation variable and the lowest in impulsivity.

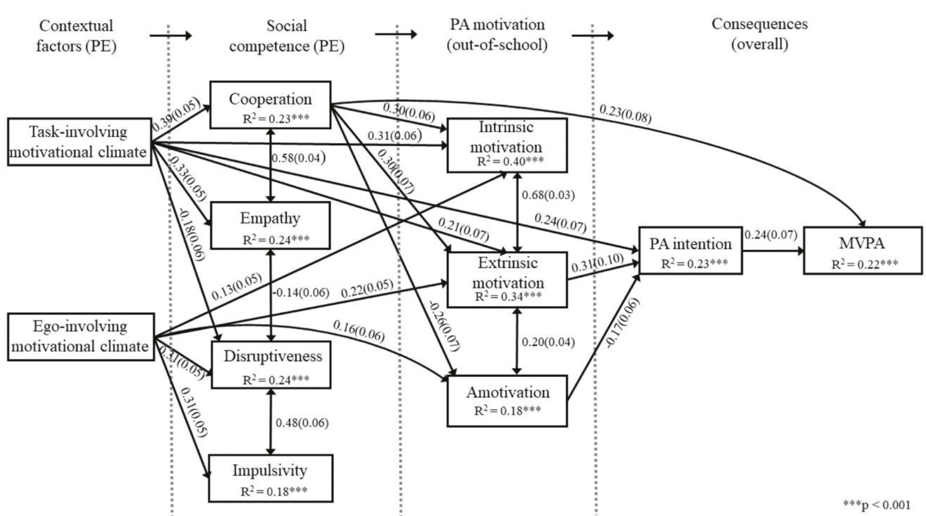

Figure 1. Standardized parameter estimates for hypothesized model. All paths are significant at $p < 0.05$ level.

Six indirect paths were found. These particular paths were from the task-involving motivational climate through cooperation, extrinsic motivation and PA intention to MVPA (standardized estimate = 0.01, $p < 0.05$); task-involving motivational climate through cooperation and extrinsic motivation to PA intention (standardized estimate = 0.04, $p < 0.01$); task-involving motivational climate via cooperation and amotivation to PA intention (standardized estimate = 0.02, $p < 0.05$); task-involving motivational climate to PA intention via cooperation (standardized estimate = 0.12, $p < 0.001$); task-involving motivational climate to extrinsic motivation via cooperation (standardized estimate = 0.12, $p < 0.001$); and task-involving motivational climate to amotivation via cooperation (standardized estimate = −0.10, $p < 0.001$).

The covariance effects of gender, school, grade, class and teacher were also analyzed. A significant covariance effect of gender on MVPA (standardized estimate = 0.16, $p < 0.01$), amotivation (standardized estimate = −0.14, $p < 0.05$) and empathy (standardized estimate = −0.22, $p < 0.001$) was noticed. In other words, boys were more physically active than girls, but had lower scores in empathy and amotivation than girls. Additionally, school had an effect on amotivation (standardized estimate = −0.71, $p < 0.01$), disruptiveness (standardized estimate = −0.89, $p < 0.01$) and impulsivity (standardized estimate = −0.59, $p < 0.01$), indicating differences between schools. Grade was related with amotivation (standardized estimate = −0.37, $p < 0.05$) and cooperation (standardized estimate = −0.37, $p < 0.05$), i.e., the higher grade, the lower amotivation and cooperation scores. The covariance effect of class was significant for intrinsic motivation (standardized estimate = 0.84, $p < 0.01$), extrinsic motivation (standardized estimate = 0.88, $p < 0.05$), amotivation (standardized estimate = 0.69, $p < 0.05$) and disruptiveness (standardized estimate = 0.90, $p < 0.05$), showing significant differences between classes. The covariance of teacher had a significant effect on intrinsic motivation (standardized estimate = −0.43, $p < 0.01$), extrinsic motivation (standardized estimate = −0.58, $p < 0.001$) and empathy (standardized estimate = −0.36, $p < 0.05$), showing that the teacher, along with their personality and teaching strategies, is connected to children's PA motivation and empathy levels.

4. Discussion

The relationship among perceptions of motivational climates, prosocial and antisocial aspects of social competence, PA motivation, PA intention and MVPA were explored in elementary school children aged between 10 and 12 years. This study extends previous research by using an SDT approach [59] directed by social competence in PE, which may promote transference of PA behavior to contexts outside of school. Primarily, our results demonstrate that, in addition to the motivational climates in school PE, the perceived social competence in school PE, particularly the aspect of cooperation, might be a significant source of children's self-determined PA motivation, PA intention and MVPA.

The hypothesized sequence of relationships [24,28] were generally supported, and as contextual factors, psychological need (social competence), PA motivation and PA intention positively contributed to students' MVPA, explaining 22% of its variance. Partly supporting previous positive findings of association between autonomous motivation and PA [25,26], we found that extrinsic motivation contributed to associations between social competence, PA intention and MVPA. The explanation for this finding may lie in the fact that our extrinsic motivation subscale included both autonomous (identified regulation) and controlling forms of motivation (introjected and external regulation), supporting the findings of Jaakkola et al. [27]. Surprisingly, there was no direct link between intrinsic motivation and PA outcomes.

There are several possible explanations for these findings. Despite the focal role of intrinsic motivation on MVPA in sport, not all the exercise activities are always intrinsically interesting. Instead of intrinsic motivation, identified regulation is identified as the main positive predictor of PA intentions in exercise activities, which may be linked to the nature of the activity [31]. Owen, Astell-Burt and Lonsdale [60] found a positive relationship between identified regulation and objectively measured PA during PE. As in our study, MVPA and out-of-school PA motivation measurements covered various

PA contexts such as competitive sport, hobbies and/or free play. Hence, it is possible that identified regulation motivation overrode intrinsic motivation.

It has also been reasoned that intrinsic and extrinsic motivation might represent more or less independent, orthogonal constructs [24,61], meaning that, in our study, only extrinsic motivation was related to MVPA via PA intention. On the other hand, despite the adequate psychometric properties of the Finnish version of the SMS in high-school students [53], this scale may not clearly differentiate between intrinsic and extrinsic motivation in primary school students. In addition, the substantial correlation between intrinsic motivation and extrinsic motivation ($r = 0.77$) complicates the indication of the unique effects of these two variables on outcomes, which may partly explain the absence of any direct link between intrinsic motivation and PA outcomes.

One central aim of this study was to explore the role of social competence within an SDT framework. In line with the SDT assumption of the need for competence [24], cooperation as an aspect of social competence in PE positively contributed to autonomous forms of PA motivation and negatively to amotivation, explaining (together with motivational climate) high proportions of variance in intrinsic motivation (40%) and extrinsic motivation (34%). In addition, and contradicting earlier findings [29,30], a direct link occurred between cooperation in PE and MVPA, implying that, by emphasizing student practice of co-operational skills and their perceptions of their own cooperation in school PE, PA motivation in out-of-school contexts might be promoted, and further, their overall MVPA. In future research, the role of cooperation should be confirmed with detailed longitudinal research designs.

One explanation for why only cooperation (and not the other aspects of social competence) predicted overall MVPA could be the nature of single items in the social competence sub-dimensions. Cooperation included items such as “I participate effectively in group activities,” which might be more prone to influence from contextual factors and inclusion of voluntary, out-of-school learning contexts, especially when compared with the items for impulsivity (e.g., “I have a short fuse”) and disruptiveness (e.g., “I argue and quarrel with peers”). Secondly, the link between cooperation and MVPA might also have to do with the content of MVPA that the participating students reflected upon. Although we did not collect data on the sport hobbies of the participating students, there is an increasing trend in Finnish 9- to 15-year-olds to do organized sports in sport clubs where team sports, such as football, are the most popular types of sports [3]. A plausible explanation for the cooperation–MVPA link is that our participants practiced team sports where cooperation between teammates is highly adaptive and necessary. On the other hand, behaviors such as interrupting, arguing and quarreling, and making fun of other students, are typically seen as undesirable negative student behaviors by PE teachers [62]. Therefore, it seems understandable that impulsivity and disruptiveness, which PE teachers typically try to constrain through disciplinary actions in PE classes, did not predict students’ out-of-school PA motivation, PA intention or their overall MVPA.

Cooperation has been shown to have positive effects on the different motivational types [30,39,63], although cooperation has been positioned as one of the social factors affecting psychological needs, not as a psychological need in itself, which complicates the comparison of the results. However, clarification is still required to distinguish the three need satisfactions [37] and the independent contributions of each individual need to motivation [64].

Results concerning the role of a task-involving motivational climate supported previous findings in which the task-involving motivational climate has been found to be positively connected to psychological needs [30], and enhance self-determined motivation in PE [41], and to be positively correlated with intrinsic motivation and increased MVPA engagement [27], whereas results concerned with an ego-involving motivational climate have been less clear. Opposite to typical findings [42,43], there was no relationship between the ego-involving motivational climate and psychological needs in terms of co-operation or empathy, and a positive relationship was found between ego-involving motivational climate and intrinsic motivation, and ego-involving motivational climate and MVPA via extrinsic motivation.

Our findings are in line with achievement goal theory, suggesting that task- and ego-involving climates have an orthogonal relationship [65], meaning that a task-involving motivational climate is independent from an ego-involving motivational climate, which might explain why only a task-involving motivational climate was associated with cooperation and empathy. This makes sense especially in this study, as a task-involving motivational climate itself, among other things, represents cooperation and personal development.

The possible psychometric challenges related to the Finnish version of the SMS may explain why an ego-involving motivational climate was positively linked to intrinsic motivation and further MVPA through extrinsic motivation. Jaakkola et al. [27] also found that there is not necessarily always a positive link between ego-involving motivational climates and reduced self-reported PA. According to Roberts, Treasure and Kavussanu [66], task-involvement in PE might prevent students' motivation towards PA participation being negatively contributed towards by ego-involvement. Furthermore, the trans-contextual perspective flavored with Finnish youth sport culture needs to be born in mind, as this may influence the relationship between students' perceptions of their ego-involving motivational climate in PE and their intrinsic PA motivation in out-of-school contexts. According to Blomqvist, Mononen, Konttinen, Koski and Kokko [67] altogether 62% of 9- to 15-year-olds participated in sport club activities, this being the highest among 11-year-olds (71%), and the bulk of these youth (76%) participated in competitive sports. Due to participants' possible competitive backgrounds, the positive link between ego-involving motivational climate in PE and out-of-school intrinsic motivation is understandable, as for these participants, social comparison and continuing rivalry might be sources of pleasure and fun in various PA contexts.

From a pedagogical perspective, our findings add to the discussion of which independent psychological need contributes the most to self-determined motivation [9,29], and how to design teaching strategies and practices that enhance social competence and increase self-determined motivation and MVPA. Despite different autonomy-supportive motivational environment designs stressing self-improvement or competence enhancing strategies implemented through well-structured environments [30] the primary source of self-determined motivation could not be represented by competence, autonomy or relatedness alone [29,30]. As a consequence, following the suggestion expressed by Sun and Chen [9], it might be fruitful to develop a more comprehensive pedagogical framework in PE, supportive of SDT, which addresses both the learning context and curriculum. This could help identify more factors and expand mechanisms by which individuals' need satisfaction and self-determined motivation, and overall MVPA could be enhanced.

4.1. Pedagogical Links between Learning Context, Social Competence, PA Motivation and the Consequences for MVPA

A number of pedagogical models in PE have sought to improve teaching and learning in ways supportive of SDT. Vasconcellos et al. [68] mentioned Teaching Games for Understanding [69,70], and Sport Education [71] as exemplars of pedagogical models "that have been shown to have positive impact on students' motivation" (p. 14). Other comprehensive pedagogical models exist which emphasize students' motivation by also drawing on taking personal and social responsibility in PE [29]. Amongst these is creative physical education (CPE) [12,72–75], so called because it involves students in teams creating a game that can be played in a sport season where team improvement is the focus.

To engender a task-involving motivational climate, CPE can be expressed through the TARGET framework [76], wherein teachers design the pedagogical context in terms of meaningful tasks (T), shared authority (A), recognition (R), meaningful grouping (G), individual evaluation (E) and a sufficient amount of time (T) for learning.

Here, CPE begins with meaningful grouping (G). The key here is being a team member: this is the most meaningful aspect of PE for students, and yet it is often downplayed by teachers. CPE is built around a team-based pedagogy, where the teams are carefully selected by the teacher and stay together for the duration of the unit. Team-based pedagogy provides a central explanatory rationale for CPE, “to explain why the behavior is truly worth the students’ effort” [77]. Being a team member is scaffolded by a series of team member levels adapted from the work of Hellison [78], through 1 (disruptive), 2 (generally cooperative), 3 (contributes when asked by name), 4 (contributes without being asked) to 5 (leads others). These levels articulate behavioral expectations, but they are not simply controlling features policed by the teacher; instead, they communicate how to be a team member, offering recognition (R) for team-supportive behavior. The accompanying rationale is that the more team members in a team operate at the higher levels, the better the teamwork, and the better the performance of that team.

Crucially, these team member levels are not introduced and managed by way of teacher control, “through messages that are rigid, evaluative and pressure inducing” [77]. They are introduced, commonly, using role play, and then team members are asked to self-assess or individually evaluate (E) their performance in a lesson against the levels, giving examples as evidence and with the emphasis on improvement in the next lesson—for the sake of the team. They self-monitor this improvement through record keeping. In this sense, these behavioral expectations are communicated via informational, noncontrolling language, and managed by each student in a way which emphasizes autonomous self-regulation.

Individuals grow together as team members through the meaningful tasks (T) they are charged with performing. The first is for each team to create a game. A feature of team-based pedagogy applied in the development of games is the use of criteria, for example, the game must be: (a) fun to play with another team, include skills A and B (such as movement skills); (b) able to be played without a designated referee or scorer (so that students are all players, the teacher is not positioned as the sole adjudicator and more than one game can occur at once); (c) inclusive of all team members playing all the time (no one is excluded); (d) inventive in the use of equipment provided (each team has the same equipment which can be shared); (e) contained within the space provided (often half a basketball court); and (f) able to be completed within ten or so minutes (this is so that during the season there is ample time in lessons for analysis and practice). These criteria are designed to enable shared authority (A): the game is not the teacher’s game but is very much the creation of the students.

Game creation occurs via a round robin process between teams, which may take three or more lessons. Teams initially draft their first imperfect attempt using the criteria. Teams are then paired, and each team has the opportunity to teach their draft game to the other team (a process which is scaffolded) and play it until the other teams understand it. Immediately following this, teams meet to discuss the other team’s draft game and to determine feedback against the criteria. This team feedback, which is consensus-driven individual evaluation (E), is recorded in a written form and passed to the other team. In this way, recognition (R) for achievement and provision of feedback is enabled via shared authority (A). At the beginning of the next lesson, teams revisit this feedback and use it to further develop their game, this time being paired with a different team to teach and play their improved game, and repeat the feedback cycle. At the conclusion of the round robin, the design of each team game contributes to the development of a class game, a process managed by the teacher. The teacher’s draft of a class game is then the focus of further cycles of review and improvement until it is ready for inclusion as the focus of a season of games. Through the season, the emphasis is on evaluation (E) of team performance and the meaningful task (T) of designing practice activities which support team improvement.

As a unit of work in PE, CPE may extend for many weeks, a sufficient amount of time (T) is required as teams grow while creating games, participating in a season and striving for improved performance: performance which is both individual (team member) and collective (team). The game creation process, and the season which follows, is designed to allow time for self-paced learning, supported socially within teams.

The task-involving motivational climate that is engendered through this pedagogical model creates a learning context that emphasizes the psychological need for not only physical competence but social competence. Being a team member combined with a team-based pedagogy creates a mastery orientation, fostering "feelings of belongingness" and cooperation [39]. The importance of cooperation is highlighted in such a learning context, which contributes to engagement in the activity for its own sake (intrinsic motivation), because it is enjoyable and interesting. Further, autonomous forms of extrinsic motivation are visible in that the outcomes of the behaviors are highly valued (identified regulation) and assimilated into personal goals (integrated regulation). Elements of introjected regulation and external regulation may also be present, especially where the team is concerned, but the shared authority enabled by the team focus is very different to that experienced when the teacher adopts a controlling motivating style [77].

The cooperative effort required in such autonomy-supportive learning contexts, concomitant with encouragement of autonomous forms of motivation, suggests the possibility of increasing MVPA in PE as well as in contexts beyond PE. While these broader contexts may be very varied—some competitive, others free play, and also including hobbies—they share a need for social competence expressed through cooperation in situations characterized by autonomous motivation.

4.2. Limitations and Strengths

The present study has some methodological limitations. First, we relied on cross-sectional data, and therefore no causal conclusions can be drawn from the identified associations between variables. In the future, longitudinal or experimental data are needed to demonstrate causality. Secondly, all measures were self-reports. Our study would have benefitted from the combination of both self-reports and the reports given by other informants, such as PE teachers or elementary school students' parents. As for MVPA, measures that are more objective would have been valuable, too. Thirdly, there is always a possibility that variance associated with the survey format affected students' responses due to slightly different data collection protocols (online questionnaires vs. paper-and-pencil questionnaires) between schools. Finally, a covariance effect did occur, even if the data were collected from two schools located in the same, typical middle-size city having equal access to local community PA facilities. Thus, our results cannot be generalized to other fourth–sixth-graders in Finland.

This present study, incorporating a relatively high number of participants, extends previous investigations taking an SDT approach by introducing social competence as an addition to physical competence, in consideration of the psychological need for competence. In this study, the introduction of social competence illuminated the circumstance where those pedagogical practices which are positively related to social competence, organized (mainly) by the PE teacher, may influence a student's out-of-school PA motivation and MVPA. With this insight comes an awareness of the importance of pedagogical innovations which support learning in the area of social competence, particularly in cooperation.

4.3. Future Directions

The connections made through this study highlight the need for more research investigating social competence as a contributor to the psychological need for competence, and its impact on motivation. This research should impact the instructional behaviors of teachers and the pedagogical practices they design. Broader implementation of pedagogical models like CPE can support this work, as they take strides in responding to the need for pedagogical change identified through research driven by theories of motivation such as SDT. In this way, this present study agrees with the findings and suggestions made via the recent literature review conducted by Vasconcellos et al. [68], which pointed to "a relative lack of objective measures of social support in the literature", necessitating "more research to understand how observable teacher and peer behaviors influence motivational processes and outcomes" (p. 14). The emphasis on peer support is central here, as promoted by CPE, supporting another finding of Vasconcellos et al. [68] "that peer support has been rarely studied in physical education", representative of "another promising area for future interventions" (p. 14).

5. Conclusions

Student motivation is an important issue in the teaching of physical education. Self-determination theory is a theoretical model which supports understanding motivation, based on the idea that three basic psychological needs impact on this motivation: autonomy needs, competence needs and relatedness needs. The need for competence is commonly interpreted in physical education literature as physical competence. This article reported a study that investigated social competence as a factor in motivation. This is a new development in the application of self-determination theory in physical education. The results of this study highlight the importance of PE teachers' use of innovative pedagogies and teaching practices, such as CPE, which involve the creation of a task-involving motivational climate emphasizing co-operation in PE lessons and units of work. This, in turn, may influence student's MVPA via out of-school intrinsic and extrinsic motivations.

Author Contributions: Conceptualization, J.K. and M.K.; methodology, J.K. and A.G.; software, J.K. and A.G.; validation, J.K. and A.G.; formal analysis, J.K., A.G. and M.K.; investigation, J.K.; resources, J.K.; data curation, J.K.; writing—original draft preparation, J.K. and J.Q.; writing—review and editing, J.K., A.G., J.Q. and M.K.; visualization, J.K.; supervision, J.K.; project administration, J.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Protocol

HRV-Guided Training for Professional Endurance Athletes: A Protocol for a Cluster-Randomized Controlled Trial

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Received: 5 June 2020; Accepted: 27 July 2020; Published: 29 July 2020

Abstract: Physiological training responses depend on sympathetic (SNS) and parasympathetic nervous system (PNS) balance. This activity can be measured using heart rate variability (HRV). Such a measurement method can favor individualized training planning to improve athletes' performance. Recently, HRV-guided training has been implemented both on professional and amateur sportsmen and sportswomen with varied results. There is a dearth of studies involving professional endurance athletes following a defined HRV-guided training protocol. The objectives of the proposed protocol are: (i) to determine changes in the performance of high-level athletes after following an HRV-guided or a traditional training period and (ii) to determine differences in the athletes' performance after following both training protocols. This will be a 12-week cluster-randomized controlled protocol in which professional athletes will be assigned to an HRV-based training group (HRV-G) or a traditional-based training group (TRAD-G). TRAD-G will train according to a predefined training program. HRV-G training will depend on the athletes' daily HRV. The maximal oxygen uptake (VO_{2max}) attained in an incremental treadmill test will be considered as the primary outcome. It is expected that this HRV-guided training protocol will improve functional performance in the high-level athletes, achieving better results than a traditional training method, and thus providing a good strategy for coaches of high-level athletes.

Keywords: HRV; endurance training; training performance; high level athletes; VO_{2max}; running

1. Introduction

It is known that training is essential for improving physical performance [1] and that optimizing training for performance improvement in athletes is an important area of research within exercise physiology and sports medicine [2–4]. In this regard, different training methods for performance improvement have been tried and tested, such as intensified training [2,5,6] and submaximal tests [7]. However, it is also recognized that using the same standardized training program for a group of athletes can provoke a wide range of reactions in terms of performance and physiological adaptations [8,9].

As stated by Schmitt, Willis, Fardel, Coulmy, and Millet [10], an important component of the interindividual variability in physiological responses to standardized training is related to the balance between the parasympathetic (PNS) and sympathetic (SNS) activity of the autonomic nervous system (ANS) [11,12]. Heart rate variability (HRV) is one of the indicators that allows the noninvasive study of autonomic nervous system activity in its sympathetic and parasympathetic branches [13,14]. HRV is understood as the variation in the time interval between two consecutive heartbeats. It is obtained by calculating the time interval that elapses between two consecutive R waves (i.e., RR interval fluctuation) on an electrocardiogram (ECG) [15]. The period between beats is not constant; consequently, high HRV values are associated with an efficient ANS, which promotes behavioral adaptation and cognitive flexibility during stress [16], whilst low HRV values are indicative of an inefficient ANS, resulting in maladaptive responses to stress and perceived threats [15]. Furthermore, HRV is considered to be an indicator of cardiovascular health level [17].

Given that the SNS is responsible for changes in heart rate (HR) due to stress, and that the HR is one of the first parameters used to control the body's functional capacity [18], HRV analysis has been established as a useful method for assessing the heart's ability to adapt to both endogenous and exogenous loads [19], and can be used for the individual assessment of responses to training loads. Indeed, in recent years, HRV has been used to analyze these imbalances between SNS and PNS in athletes [20] and to evaluate different aspects related to training [21] such as exercise intensity and duration [22], recovery and overtraining [23], training load [24] or psychophysiological profiles [25].

The control of training based on HRV, as an indicator of the precompetitive physical and psychological state in athletes, enables coaches and scientists to use these HRV records to adapt the recovery and training loads to each athlete in search of a better sports result. As indicated by Ortigosa-Márquez, Reigal, Carranque, and Hernández-Mendo [26], high HRV values indicate more parasympathetic than sympathetic activation in an athlete and, therefore, better recovery and preparation for dealing with high-intensity training sessions.

Traditionally, HRV has been measured with ECG [14]. One of the ways of quantifying HRV is through rMSSD (the root mean square of successive differences between adjacent RR intervals) [26] since it is a temporal statistical parameter that reports those variations occurring over the short term between RR intervals [27] and it is used to observe the influence of the SNP on the cardiovascular system [18]. Currently, there are other validated tools for determining HRV that facilitate measurement, such as the Kubios HRV, Elite HRV, Mobile Lab and HRV4Training applications (apps).

In recent years, experimental studies have been carried out evaluating HRV-guided training in endurance athletes. These studies have been conducted both on elite athletes in sports such as cycling [24] and skiing [10], and with amateur endurance athletes [28–31]. One should take into account the scarcity of studies that have been published to date, especially on elite-level endurance athletes, as well as the absence of a common protocol to follow in this type of research.

The protocol proposed in the present study contributes to the scientific literature in this field in several ways: (i) it proposes research focused on elite athletes, a sample population for which only two experimental studies have been carried out to date; (ii) the protocol is intended to research endurance runners, for which we are not aware of any research having been carried out on this type of sample and with these characteristics at the international level. Therefore, it is a novel study aiming to provide empirical support for HRV-guided training in long-distance runners, adapting daily training to the physiological responses of each individual athlete. The performance of these athletes could be compared to that of another group of long-distance runners who carry out traditional training over the same period of time.

Until just a few years ago, conducting research of this type, involving daily HRV measurements on each athlete and then adapting training based on these data, was only possible with the collaboration of high-cost laboratories. This study tests the use of noninvasive, commercial, low-cost and publicly accessible technology to evaluate the physiological responses obtained by adapting training to HRV.

Based on everything described above, we hypothesize that HRV-guided training will: (i) improve functional performance in high-level athletes and (ii) produce better performance results than a traditional training method. The objectives of the proposed protocol are: (i) to determine changes in the performance of high-level athletes after following an HRV-guided or a traditional training period, and (ii) to determine differences in the athletes' performance after following both training protocols.

This will be a 12-week cluster-randomized controlled trial protocol in which professional athletes are assigned to either an HRV-based training group (HRV-G) or a traditional-based training group (TRAD-G). A block randomization method will be chosen to randomly assign participants to interventions in equally sized sample groups. This protocol has been designed following the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) Statement [32]. To describe the intervention, the TIDieR (Template for Intervention Description and Replication) checklist by Hoffmann et al. [33] has been used.

2. Materials and Methods

2.1. Study Setting

To detect an intervention-related effect in professional athletes, other studies with similar protocols [24,31] compared athletes from two clubs or associations. Similarly, our sample will comprise athletes from two sport institutions in Almería (Spain): the C.D. Atletas de Almería, based in the city of Almería (Spain) and the Asociación Espeleológica Velezana, based in Vélez Rubio (Spain).

2.2. Eligibility Criteria

The inclusion criteria for participating in the program will be: (i) to belong to the Spanish Athletics Federation; (ii) to have been training and competing in Spanish Athletics Federation competitions for at least two years; and iii) to be in the first third of the classification for the last five races of the previous season. Regarding the exclusion criteria, the following will be taken into account: (i) having cardiovascular pathologies, abnormal blood pressure parameters or diagnosed respiratory problems; (ii) being treated for psychological problems, or regularly taking a drug(s) that has a direct or indirect effect on the nervous system (e.g., anxiolytics, antidepressants or neuroleptics); (iii) substance use that is not permitted by the International Association of Athletics Federations (IAAF); (iv) occasional consumption of medication for a disease related to the cardiorespiratory system (e.g., influenza) that might alter performance and (v) not performing at least 90% of the workouts during the intervention.

The trial steering members will be responsible for checking that the subjects interviewed meet the inclusion criteria. The Spanish Athletics Federation's medical team will certify that the subjects do not meet any of the exclusion criteria. After being informed of the study design and potential risks, all athletes will sign a written informed consent document. The model consent form is shown in Appendix A.

2.3. Interventions

Based on the methodology used by Javaloyes et al. [24] and Vesterinen et al. [31], the intervention will be divided into two training periods for both study groups (HRV-G and TRAD-G): a four-week preparation period (PR) and an eight-week training period (TR). Both will maintain the weekly training volume. The training carried out will mainly be running. The PR period will be common to both groups and will be a familiarization phase for the training sessions and their intensities. During this period, the training intensity will gradually increase for the first three weeks and then decrease in the fourth week. This will mean three weeks of overloading and one week of recovery (3:1). The training to be carried out by the athletes is presented in more detail in Table 1. In the TR period, each group will carry out the corresponding intervention. The TRAD-G group will train according to a predefined training program, which will include sessions carried out at low intensity (approximately 50% of the total), and other sessions of moderate and high intensity, with a structure similar to that carried out during the PR period (Table 2). The training prescribed to the HRV-G group will depend on the subjects' HRV, in accordance with authors such as Javaloyes et al. [24], Kiviniemi, Hautala, Kinnunen, and Tulppo [34], and Lamberts, Swart, Noakes, and Lambert [35].

Table 1. Periodization and training distribution for the heart rate variability group (HRV-G) and traditional-based training group (TRAD-G) during the preparation period (PR).

Weeks	High Intensity		Moderate Intensity	Low Intensity
1			90 min between VT1 and VT2	3–4 sessions between 30 and 35 min below VT1
2		4 × 12 min > VT2/3-min rest	90 min between VT1 and VT2	2–3 sessions between 30 and 35 min below VT1
3	50 min at VT2	4 × 12 min > VT2/3-min rest	90 min between VT1 and VT2	2–3 sessions between 30 and 35 min below VT1
4				3–4 sessions between 30 and 35 min below VT1

Note: VT1 = first ventilatory threshold; VT2 = second ventilatory threshold. High-intensity and moderate-intensity sessions will be performed with a 15- to 20-min warm up and 20 min of cooling down.

Table 2. Periodization and training distribution for TRAD-G during training period (TR).

Weeks	High Intensity		Moderate Intensity	Low Intensity
5	50 min at VT2			3–4 sessions between 30 and 35 min below VT1
6		4 × 12 min > VT2/3-min rest	90 min between VT1 and VT2	2–3 sessions between 30 and 35 min below VT1
7	50 min at VT2	4 × 12 min > VT2/3-min rest	90 min between VT1 and VT2	2–3 sessions between 30 and 35 min below VT1
8				3–4 sessions between 30 and 35 min below VT1
9	50 min al VT2			3–4 sessions between 30 and 35 min below VT1
10			90 min between VT1 and VT2	2–3 sessions between 30 and 35 min below VT1
11	50 min al VT2	4 × 12 min > VT2/3-min rest	90 min between VT1 and VT2	2–3 sessions between 30 and 35 min below VT1
12				3–4 sessions between 30 and 35 min below VT1

Note: VT1 = first ventilatory threshold; VT2 = second ventilatory threshold. High-intensity and moderate-intensity sessions will be performed with a 15- to 20-min warm up and 20 min of cooling down. Approximately 50% of the total sessions will be at low intensity.

To quantify the HRV, a Smartphone application known as "HRV4Training" (see http://www.hrv4training.com/) will be used. This tool has been validated by Plews et al. [36], showing a low typical estimate error (CV% (90% CI) = 3.8 (3.1; 5.0)) and a clear electrocardiographical correlation (r = 1.00 (1.00; 1.00)). It provides the root mean sum of the successive differences between R – R intervals (rMSSD) data using photoplethysmography. rMSSD is more suitable and reliable than other indexes [13,37]; nonetheless, the HRV data will be transformed by taking the natural logarithm, thus allowing parametric statistical comparisons that assume a normal distribution. In this way, a 7-day rolling average will be calculated (LnrMSSD$_{7\text{-d}}$). The PR period will be used as a standardized phase to obtain the baseline LnrMSSD$_{7\text{-d}}$ and its range of normality (upper and lower limits). Following the indications of Plews, Laursen, Kilding, and Buchheit [38], this will be calculated as the mean ± 0.5 × SD. During the TR period, the LnrMSSD$_{7\text{-d}}$ will be calculated daily in order to adapt the training prescribed to the HRV-G athletes. Moreover, the range of normality will be updated weekly. If the LnrMSSD$_{7\text{-d}}$ is within the range of normality, the athletes will perform a moderate or high-intensity session. If the weekly LnrMSSD$_{7\text{-d}}$ average falls below the normal range, a low intensity workout or rest will be undertaken. Athletes will perform a maximum of two consecutive sessions of moderate or high intensity; likewise, they will not accumulate more than two consecutive rest sessions. The modified scheme of Kiviniemi et al. [34] presented in Figure 1 will be followed.

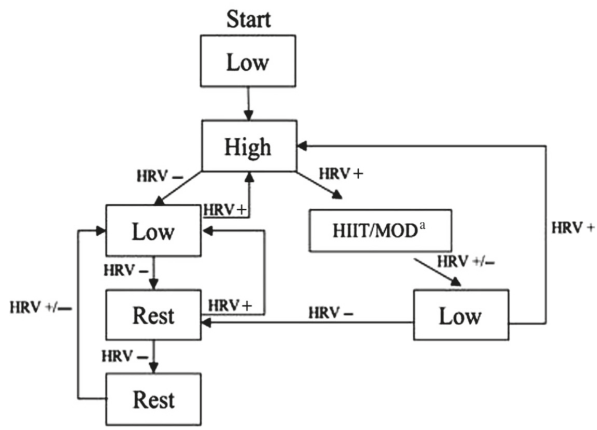

Figure 1. HRV-guided training schema. Modified from Kiviniemi et al. [34]. Note: When LnrMSSD7-d remained inside their normal range, high-intensity or moderate-intensity training sessions were prescribed. If LnrMSSD7-d fell outside their normal range (below), low intensity or rest were prescribed. HIIT/MOD = high/moderate-intensity interval training; HRV = heart rate variability; LnrMSSD7-d = 7-day rolling average of the natural logarithm of the root-mean-squared differences of successive RR intervals.

In accordance with Javaloyes et al. [24], all participants will be instructed to measure their HRV data at home each morning after waking up and emptying their bladders. They will be instructed to lie in a supine position and not perform any further activity during the recordings. Data will be recorded over a 60-s period e.g., [36]. The daily control and recording of the rMSSD, as well as the $LnrMSSD_{7\text{-}d}$ calculation used to prescribe the training of the HRV-G athletes, will always be carried out by the trial steering members. These members will receive the information from each athlete via phone or email and, in turn, will inform the HRV-G coach of the training intensity corresponding to each athlete. This procedure will also serve as a strategy for maintaining and monitoring the athletes' adherence to the training programs. Concomitant care, or any other intervention, will not be allowed during the trial for either the HRV-G or the TRAD-G. Athletes from both groups will carry out the training in their usual location.

2.4. Outcomes

The primary outcome of this study will be the maximal oxygen uptake (VO_{2max}) obtained in an incremental treadmill test. The secondary outcomes will be: the maximal speed in m/s, maximal heart rate, respiratory exchange ratio, ventilatory thresholds (VT1 and VT2) and their derived speed, heart rate, respiratory exchange ratio and VO_2 obtained in the incremental treadmill test. Other measurements considered as secondary outcomes will be: the time, speed, heart rate, rating of perceived exertion (RPE) and lactate in the 3000 m running test. Body composition and rMSSD will be considered as other variables.

Measurements will be taken before and after the training period, which will correspond to weeks 5 (pretest) and 12 (post-test). Over the assessment weeks, care will be taken that participants do not carry out any high-intensity training sessions. Each assessment week will consist of two testing sessions with a 48-h recovery period. The first testing session will include maximal graded exercise test and body composition measurements. In the second testing session, athletes will perform a 3000 m running test. The rMSSD will be measured daily, as explained in the intervention section.

The incremental treadmill test will be performed by the Physical Exercise and Human Performance Research Group at the University of Murcia (Spain). This is a more objective way of determining physical fitness and represents the maximal performance capacity of an individual [39]. First, with the athlete in the supine position, a cardiovascular examination will be carried out at rest by means of cardiac auscultation, blood pressure and an electrocardiogram (ECG). The electrodes for recording the ECG and heart rate will be kept in place throughout the test. The Cardioline Cube® electrocardiograph will be used. To perform the incremental treadmill test, the Runner srl (Cavezzo Italy) treadmill will be used, as it was in other studies such as Ballesta-García, Martínez-González-Moro, Ramos-Campo, and Carrasco-Poyatos [40]. Similar to other studies, such as Nuuttila et al. [30] or Vesterinen et al. [31], a prior 2-min aerobic warm up will be performed at 6 km/h. The test itself will start at a velocity of 7 km/h. The speed will be increased by 0.1 km/h every 6 s. The incline will remain at 1% throughout the test. The athletes will be encouraged to perform at maximum effort. The test will end when the subject can no longer run; the subject will indicate this with a hand gesture. The recovery phase will then begin at 4km/h for 3 min followed by rest for a further 2 min. The tests will be considered maximal and valid when the theoretical heart rate (220-age) exceeds 85% and the respiratory exchange ratio (RER) is greater than 1.15 [41]. During the stress test, the subjects will breathe through a mask connected to a gas analyzer (Metalyzer 3b®, Cortex, Leipzig, Germany). All gas exchange parameters will be measured breath-by-breath and averaged every 30 s. The VO_{2max} will be defined as the oxygen consumption plateau [42]. The aerobic (VT1) and anaerobic (VT2) thresholds will be determined. Before each test, the gas analyzer will be manually calibrated. The test's maximal speed (V_{max}), maximal heart rate (HR_{max}), and respiratory exchange ratio (RER) will be recorded. The V_{max} or HR_{max} will be defined as the highest speed, or heart rate, reached for a finished stage. The speed, heart rate, respiratory exchange ratio and VO_2 at each ventilatory threshold will also be recorded as $V_{VT1,}$ V_{VT2}, HR_{VT1}, HR_{VT2}, RER_{VT1}, RER_{VT2}, VO_{2VT1}, and VO_{2VT2}, respectively. All tests will be carried out under similar environmental conditions (an ambient temperature of 20–22 degrees).

As in other studies [30,43], the 3000 m running test will be conducted individually on a 400 m outdoor running track. Participants will be instructed to run at their maximum speed. Before the test, a 15 min standardized aerobic warm-up will be performed, consisting of running at a low to moderate intensity. Capillary blood samples (5 μL) for blood lactate concentration analysis will be taken from the fingertip using a Scout+ analyzer (SensLab GmbH, Leipzig, Germany). Lactate is considered a useful indicator for measuring the metabolic cost and intensity of effort in aerobic-anaerobic sports [44]. Following Ribas [45], it will be considered in this test to relate it to running intensity. Lactate samples will be taken at four different points in time, in accordance with Rodríguez and Valero [46]: (i) just before the test ($Lactate_{pre}$), (ii) just after the test ($Lactate_{post}$), (iii) 3 min after the test ($Lactate_{post3}$) and iv) 5 min after the test ($Lactate_{post5}$). Other variables, such as heart rate, time, speed, and rated perceived exertion (RPE), will also be measured. Heart rate will be recorded at five different points in time: (i) just before the test (HR_{pre}), (ii) just after the test (HR_{post}), (iii) 1 min after the test (HR_{post1}), (iv) 3 min after the test (HR_{post3}) and v) 5 min after the test (HR_{post5}). The time will be recorded every 1000 m at three different points in time: (i) after running 1000 m, (ii) after running 2000 m and (iii) after running 3000 m (right at the end of the test). The speed will be calculated from these three points using the formula: speed = distance in m/time in seconds. The RPE will be measured at the end of the test using the modified Börg CR-10 scale of perceived exertion [47]. According to the authors, a 0 rating corresponds to rest; a 3 rating to moderate intensity; a 5 rating to hard intensity; a 7 rating to very hard intensity; and a 10 rating to maximal intensity. This tool has recently been determined as a stand-alone method for training load monitoring purposes in several sports and physical activities with men and women in different age categories (children, adolescents and adults) at various expertise levels [48].

Body composition will be analyzed just before the treadmill test using the InBody120 analyzer (Biospace Co. Ltd., Seoul, South Korea). Height will be measured using a measuring rod (Seca 213), and the body mass index (BMI) will be calculated according to the formula: BMI = kg/m^2.

The time schedule for enrolment, interventions and assessments is shown in Figure 2.

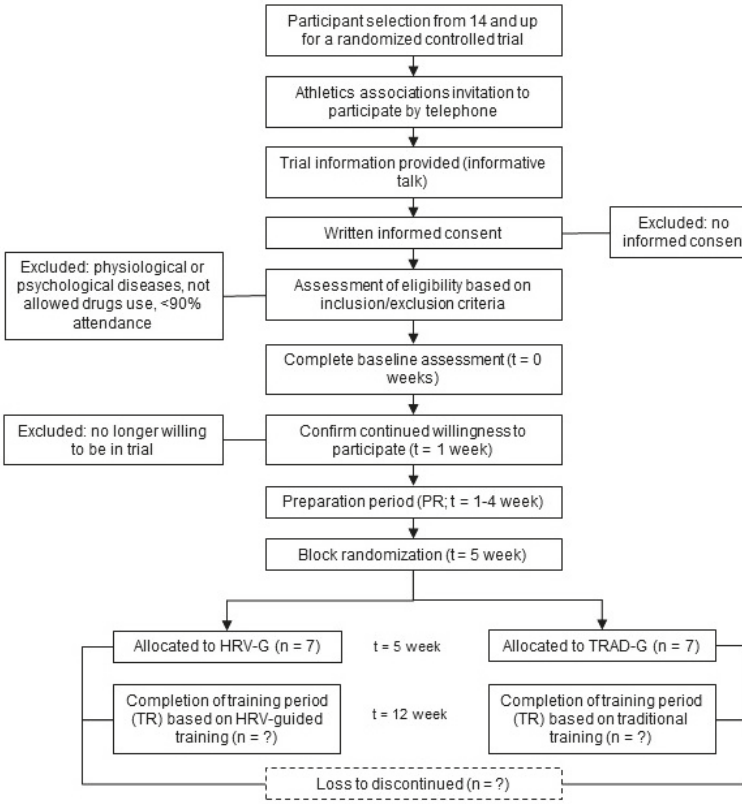

Figure 2. Schedule of enrolment, interventions and assessment. Note: HRV-G = heart rate variability-based training group; TRAD-G = traditional based training group; PR = preparation period; TR = training period.

2.5. Sample Size and Power

Calculations to establish the sample size will be performed using RStudio 3.15.0 software (PBC, Boston, USA). The significance level will be set at $p \leq 0.05$. According to the mean standard deviation established for VO_{2max} in a previous study [31] (SD = 1.5 mL/kg/min) and an estimated error (d) of 1.1, a valid sample size providing a 95% confidence interval (CI) in each group will be 7 ($n = CI^2 \times d^2/SD^2$). Thus, a final sample size of 7 for each group will provide a power of 93% if between and within a variance of 2.

2.6. Recruitment

Each club or association involved in athletics in Almería (Spain) will be screened to identify the percentage of high-level or professionally federated athletes. When there are at least 7 high-level or professionally federated athletes, the club/association officers will be contacted by telephone to inform them of the study objective. Once they agree, an informative talk will be carried out with the athletes and the coach to inform them of the study objective, the time period in which it will take place, and the required commitment by the athletes to measure their daily HRV according to the established protocol, to attend the pre and post-test sessions and to attend at least 90% of the training sessions. The coaches will be informed of the required commitment to adapt each athlete's training session to the daily HRV score if their club is randomized into the HRV-G group. If they agree to participate, then they will have to sign the written consent and meet the eligibility criteria necessary to be recruited into the study. The recruitment process will be conducted by the trial steering members.

2.7. Allocation and Blinding

A block randomization method will be used to allocate participants to the groups, which will contain equal sample sizes. The block size will be determined by the data monitoring committee according to the statistical power provided. Blocks will be chosen randomly by tossing a coin to determine the participants' assignment into the groups. This procedure will be carried out by the data monitoring committee. The athletes and the data monitoring committee will be blinded to the exercise group assignment.

2.8. Data Analysis

Data will be analyzed using Jamovi (Jamovi Project 2018, version 0.9.1.7, Sydney, Australia) and RStudio 3.15.0 software (PBC, Boston, MA, USA). Prior to data analysis, the Shapiro Wilk test and the Levene test will be performed to determine the normal distribution of the variables and the homogeneity of variance. Descriptive data will be reported as mean ± SD and range. All the data will be analyzed based on the intention-to-treat principle (last observation carried forward). If the sample is normally distributed, Student's t-test will be calculated to compare variables before and after the intervention. For a variable to be considered as having a normal distribution, 95% of values will have to be within two standard deviations of the mean. If the sample is nonparametric, the U-Mann Whitney test will be used to compare variables before and after the intervention. The standardized mean differences (Cohen's effect size) will be calculated together with the 95% confidence intervals [49]. The effect sizes (ES) will be calculated using Cohen's d [49]. The relationship between variables will be assessed using the Pearson r correlation coefficient. If r is higher than 0.7, the determination coefficient (r^2) will be used to determine the percentage of Y variation with regard to the X variation. Significance will be accepted at $p \leq 0.05$.

2.9. Monitoring

A data monitoring committee will be set up during the study recruitment period. Interim analyses will be supplied to the committee in strict confidence, together with any other analyses that the committee may request. Based on the data monitoring committee's advice, the trial steering members will decide whether or not to modify the trial intake.

In our study, an adverse event will be defined as any untoward medical occurrence in a subject without regard to the possibility of a causal relationship. Adverse events will be collected after the subject has provided consent and enrolled in the study. If a subject experiences an adverse event after the informed consent document is signed (entry) but the subject has not started to receive study intervention, the event will be reported as not being related to the study's exercise program. For this study, the following will be considered serious adverse events: severe or permanent disability, use of prohibited substances and any other significant hazard as determined by the study members. Serious adverse events occurring after a subject has stopped participating in the study will not be reported unless the researchers feel that the event may have been caused by the study protocol procedure.

2.10. Ethics and Dissemination

This protocol, the informed consent template contained in Appendix A and other requested documents (if any) will be reviewed and approved by the Bioethical Committee at the University of Almería with respect to the scientific content and compliance with applicable research and human subject regulations. Following initial review and approval, this protocol will be reviewed by the researcher at least once a year at Clinicaltrials.org, where it is registered with the ID: NCT04150952.

Any protocol modifications which might have an impact on conducting the study, potentially benefit a subject or affect a subject's safety, or change the study objectives, study design, subject population, sample sizes, study procedures, along with significant administrative issues, will require a formal amendment to the protocol. Such an amendment will be agreed upon by the Bioethical Committee at the University of Almería prior to implementation, and the clubs/associations enrolled will be notified. Administrative changes to the protocol that are minor corrections, and/or clarifications having no effect on the way the study is to be conducted, will be agreed upon by the researchers and documented in a memorandum. The Bioethical Committee at the University of Almería may be notified of the administrative changes.

All study-related information will be stored securely at the study site. All records that contain names or other personal identifiers, such as locator forms and informed consent forms, will be stored separately from the study records and identified by a code number. Forms, lists, logbooks, appointment books and any other listings that link participant ID numbers to other identifying information will be stored in a separate, locked file.

3. Discussion

This protocol describes the rationale, design, and methods of an HRV-guided training design for professional endurance athletes. It will allow accomplishment of a randomized controlled intervention to determine changes in the performance of high-level athletes after following an HRV-guided or a traditional training period, Moreover, the differences in the athletes' performance after following both training protocols will be determined. To design this protocol with professional endurance athletes, the guidelines described in Kiviniemi et al. [34] have been followed. This procedure has also been adapted in other professional sports such as cycling [24,50] and skiing [10], as well as to amateur endurance athletes [28–31].

This is the first time that this kind of protocol will be applied in endurance elite athletes. After its implementation, we expect that both high-level athletes groups (HRV-G and TRAD-G) improve: (i) VO_{2max} and other secondary outcomes measured in the treadmill test (the maximal speed in m/s, maximal heart rate, respiratory exchange ratio, or ventilatory thresholds), (ii) the time, speed, heart rate, rating of perceived exertion (RPE) and lactate in the 3000 m running test. Additionally, HRV-G will be better regarding performance results than the TRAD-G. These findings will suggest that training guidance balancing the sympathetic and parasympathetic autonomic nervous system leads to greater athletic performance in endurance athletes compared to standardized prescribed training. This is relevant for training optimization and for minimizing overuse and reducing injury risk.

4. Conclusions

Experimental research conducted in recent years shows that improvements in variables related with athletes' performance (e.g., VO_{2max}) can be obtained through HRV-guided training. However, accordingly to these studies, results do not allow a consensus to be established regarding the performance benefits of HRV-guided training for endurance athletes.

From studies carried out until now, this article describes a novel protocol to conduct a randomized controlled trial with endurance athletes. So far, no other HRV-guided training research has been conducted with these types of professional athletes. Besides, this protocol proposes to use emergent technologies in the training and the research fields, such as smartphone applications; in this case, HRV4training, an app scientifically validated that allows calculation of the daily HRV measurement for each athlete. Although more research is needed, the implementation of the protocol described here will contribute to this scientific field of study.

Author Contributions: Conceptualization, M.C.-P., A.G.-Q. and A.G.-G.; methodology, M.C.-P., A.G.-Q., A.G.-G. and I.M.-G.-M.; investigation, M.C.-P., A.G.-G. and A.G.-Q.; writing—original draft preparation, M.C.-P. and A.G.-Q.; writing—review and editing, A.G.-G. and I.M.-G.-M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Mr. Antonio Granero-Gallegos and Ms. María Carrasco-Poyatos, lead researchers on the project: Physiological and psychological effects from heart rate variability-based training in professional athletes have informed:

Mr/Ms . . . . ID. . . . . , about the present study's general proceeding, its objectives, duration, purpose, inclusion and exclusion criteria, associated risks and benefits, as well as the possibility of leaving it without having to give reasons. In knowledge of all the above, and the measures that will be adopted to protect the participant's personal data, according to the current regulations,

I CONSENT to participate in the present research.

Signed: Mr/Ms . . . . ID. . . . .

Signed: Mr. Antonio Granero-Gallegos, ID 23245990M and Ms. María-Carrasco-Poyatos, ID 75096834V

Project Leading Researche.

Antonio Granero-Gallegos María Carrasco-Poyatos

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International Journal of
Environmental Research and Public Health

MDPI

Review

Assessment in the Supine-To-Stand Task and Functional Health from Youth to Old Age: A Systematic Review

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Received: 28 April 2020; Accepted: 27 July 2020; Published: 10 August 2020

Abstract: Performance in the supine-to-stand (STS) task is an important functional and health marker throughout life, but the evaluation methods and some correlates can impact it. This article aims to examine the studies that assessed the performance of the STS task of young people, adults and the elderly. Evidence of the association between the STS task and body weight status, musculoskeletal fitness and physical activity was investigated, and a general protocol was proposed. MEDLINE/Pubmed and Web of Science databases were accessed for searching studies measuring the STS task directly; identification, objective, design, sample, protocols and results data were extracted; the risk of bias was assessed (PROSPERO CRD42017055693). From 13,155 studies, 37 were included, and all demonstrated a low to moderate risk of bias. The STS task was applied in all world, but the protocols varied across studies, and they lacked detail; robust evidence demonstrating the association between STS task and musculoskeletal fitness was found; there was limited research examining body weight status, physical activity and the STS task performance. In conclusion, the STS task seems to be a universal tool to track motor functional competence and musculoskeletal fitness throughout life for clinical or research purposes.

Keywords: psychomotor performance; functional evaluation; human development; righting skill; rising from the floor; floor-to-stand; supine rise tasks

1. Introduction

The human development lifespan perspective provides a framework for studying the changes that occur throughout life [1,2]. Within this perspective, some motor actions are considered developmental milestones and health indicators as the action "rising from a supine position on the floor to an erect standing position" (supine-to-stand, STS), since it is an indicative of bipedal readiness for upright locomotion in children [3] and functional capacity for independence in the elderly [4].

The STS task performance also uncovers an individual's level of motor competence (MC), defined as the proficiency in motor actions performed with coordination and control [5–7]. The STS task requires complex coordination of large muscle groups of the trunk and extremities, while controlling their center of mass in dynamic balance during elevation and stabilizing body alignment during the erect posture [8].

During the 1980s, Ann Vansant proposed developmental sequences for this righting task [1,3,9]. Studies related it to physical fitness and lifestyle variables [10–12] expanding the focus of motor development *per se*, to the discussion concerning their relationship with health [6,7]. STS has been investigated at different stages of life [4,8,12–14], and unlike other motor skills, such as running or jumping, instruction on how to rise from supine is not taught, which reduces the bias of cultural context or structured practice opportunities. Furthermore, the STS task seems to be a useful marker of health and function problems, predicting serious fall-related injuries [15–17].

With these characteristics, maybe the STS task is a useful and practical method to monitor functional MC changes throughout human life and an excellent candidate to be a universal screening tool. However, such assumptions need further examination. For example, health variables as physical activity, musculoskeletal fitness, and body status weight should be considered when evaluating the STS task [14].

Assessing the performance of the STS task or other motor action may involve two different measurement approaches: process and product-oriented. A process-oriented measurement aims to express the quality of the movement, in general, by comparing it with the more successfully mechanical form, as described in the checklists. A product-oriented measurement aims to describe the action results, such as the time to complete a task or the scores on a target, using interval or discrete variables (e.g., seconds, points, speed). Both approaches, complementary, expresses human motor performance [18,19]. Studies using a product-oriented approach measured the STS time by chronometers [20], photoelectric cells [4], or a video [8,12,14,21–24]. STS process-oriented measurements often uses video recordings, to check the postures [23] or motion sequences [9,10]. Such protocols do not always control procedures as verbal instructions or the number of trials. All of these differences lead to non-standardized performance reporting. As far as we know, there are no studies that have established a full protocol for assessment of the STS task for all ages.

According to PICO strategy, the research problem presented in this study asked if, in typical development individuals (P), the assessment of the STS task performance (I) used in different developmental phases (C) can monitor healthy functional MC changes (O). In this context, the main objective was systematically reviewing the supine-to-stand task assessment methods and the health variables related to this task in youth, adults, and older adults. Specifically, it was examined: [1] The methods used to investigate the STS task, including the risk of bias, and the results, [2] the evidence of an association between the performance of the STS task and the health-related variables body weight status, musculoskeletal fitness, and physical activity. Finally, as a by-product of this review, a protocol for STS task measurement, which is testable across the lifespan, was proposed.

2. Materials and Methods

The present review included studies of the several designs (observational, interventional, cross-sectional, longitudinal), so it can be better classified as a mixed-methods review [25]. This study is registered in PROSPERO (#CRD42017055693) and followed protocols for systematic reviews PRISMA-P [26].

2.1. Data Sources and Searches Descriptors

In this review, studies with healthy individuals in the phases of childhood, adolescence, adulthood, and senescence whose performance on the STS task had been assessed through objective measures, but not questionnaires, were searched. The databases were directedly accessed (MEDLINE, Scielo, EMBASE, Scopus, ERIC/ProQuest), and also it was used some search device (PubMed, Web of Science—Main Collection, Science Direct, EBSCO, Cochrane). Subsequently, the search involved gray literature, through the review of the reference lists (only of the included articles, see below) and consultation with specialists in the area. Intragroup descriptors were combined using the Boolean expression OR, whereas between-group descriptors were combined using AND (Figure 1). Inclusion criteria were: (1) Original studies (articles, theses, dissertations) assessing the STS task by using objective measures, (2) English language, (3) healthy/typical development individuals. Exclusion criteria were: (1) Duplicates, (2) not match with the background of this review, (3) not typical individuals, (4) articles not available in full text. There were no restrictions on the year of publication.

Web of Science—Main Collection	TOPIC: ((“functional assessment” OR “task performance and analysis” OR movement OR posture)) AND TOPIC: (“supine position” OR lifting OR “ris* from the floor” OR “ris* from supine” OR “stand* from supine OR “ris* from the ground” OR “supine to stand” OR “stand up” OR “supine position to erect stance” OR “ris* from a supine position” OR “get* up from the floor” OR “supine-to-stand task” OR “right* task” OR “right* skill” OR “stand upright” OR “lying backwards to stand”) Refined by: LANGUAGES: (ENGLISH) Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.
PubMed/MEDLINE	(MeSH Terms)) OR movement [MeSH Terms]) OR exercise therapy [MeSH Terms]) OR physical therapy [MeSH Terms]) OR physical therapy [MeSH Terms] AND floor and floorcoverings [MeSH Terms])) OR lifting from the floor OR rising from the floor OR standing up from the floor) OR supine-to-stand task) OR supine-to-stand task)
Scielo/Science Direct/EMBASE/Scopus/ERIC/EBSCO/Cochrane	(“functional assessment” OR “task performance and analysis” OR movement OR posture) AND ((standing) OR “rising from the floor” OR “supine-to-stand task” OR “getting up from the floor” OR “standing up”)

Figure 1. Descriptors used in the systematic review about the supine-to-stand (STS) task performance, according to research tools in the databases. The figure was originally created by the authors.

2.2. Study Selection

One author (MTC) conducted the identification of the studies, and added it to Rayyan QCRI, a web application for systematic reviews [27]. In this environment, the duplicates were removed by MTC. Before initiating the screening process, MTC and FSS performed an exhaustive training to include articles until they reached a concordance of the 92%; then, these two authors reviewed the list of titles for applying the inclusion criteria. So, the authors compared the results and discussed the discrepancies until they reach a consensus. If there was no consensus about a title, a third researcher resolved the disagreement (MPS). Such a process was repeated, reviewing abstracts and full texts, again applying the inclusion criteria. The identification of articles in the list of references and consultation with specialists supplemented the search strategy, added to the Rayyan application.

2.3. Data Extraction and Methodological Quality Assessment (Risk of Bias)

There was the extraction of the following data: Identification (author, year, and country of publication); objective, design, sample characteristics; STS outcome (process or product-oriented); results/conclusion strictly related to the STS task (Table 1). The number of trials, instruction for performance pace, participant's caring, and motivational strategies from the protocols' studies were also extracted (Table 2).

The quality of each article (risk of bias) was examined by 15 questions adapted from Law [28], and the scoring was as follows: 0 = does not meet criteria; 1 = satisfies the criteria; ? = not clearly described; NA = not applicable. In the classification, a study with score ≤ 7 = high risk of bias/low quality; studies that reached 8 to 11 points = moderate risk of bias/medium quality; scores ≥ 12 = low risk of bias/high quality (Supplementary material Table S1). Two researchers conducted these data extraction (MTC and FSS), and when there was no consensus, another researcher (ABD) resolved the disagreement.

The data were summarized in tables, and a narrative synthesis was done. Lastly, a full protocol was developed from the critical knowledge generated here. Some authors in this review worked in the clinical setting, and others are specialists in movement analysis, both in children and in the elderly. Then, the theoretical background and practical experience contributed to the presentation of this final protocol (Appendix A, Box A1).

3. Results

In this review, from of 13,155 studies found, 37 articles were included (Figure 2) [8,11,12,14–17,20–24,29–35]. The studies investigated subjects ranging in age from 1 to 94 years; the largest proportion of studies investigated up to 100 subjects [11,14,17,31,36–40], and one of them [41] examined a very large sample with 2368 subjects; more than a third of them used both process and product-oriented measurements (Table 1); only one study combined these two approaches creating a full score (MOD score) [40].

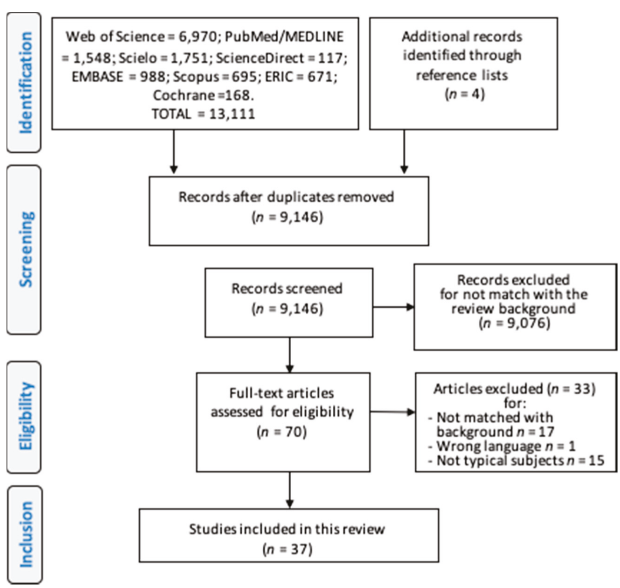

Figure 2. Flowchart describing the process to include studies in the systematic review according to the PRISMA-P protocol. The figure was originally created by the authors.

Table 1. Methodological characteristics, main results, and conclusions from studies on STS task (ordered by developmental phase and year of publication). The table was originally created by the authors.

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
			Childhood		
VanSant (1988) [3]; US	(1) To determine whether within the STS task MPs of different body regions vary with age, (2) describe movements used by children to perform this task.	OBS/pre-longitudinal/NP; 120 children divided into 4, 5, 6, and 7-year-old groups with 30 subjects each, matched by gender; G1 = 4.5 ± 0.27 yrs., G2 = 5.41 ± 0.28 yrs., G3 = 6.5 ± 0.27 yrs., G4 = 7.33 ± 0.24 yrs.	Process—MPs categories (UE, AX, and LE regions).	-	(1) Age differences in the incidence of MPs in each body region. (2) A trend toward increased symmetry of MPs as age increased. (3) The oldest subjects did not commonly use the symmetric form when rising. (4) Changes in the STS task likely to continue beyond early childhood.
Marsala and VanSant (1998) [24]; US	(1) To describe the MPs of toddlers on the STS task; (2) To determine whether toddlers' MPs differ with age; (3) investigate whether MPs occur earliest in the development of this task prevail in toddlers.	OBS/pre-longitudinal/NP; 60 toddlers: 20 aged 15–25 months (mean age = 20.5 ± 2.9 mo.); 19 aged 26–36 months (mean age = 30.2 ± 2.6 mo.); 20 aged 37–47 months (mean age = 43.5 ± 2.6 mo.).	Process—MPs categories (UE, AX, and LE regions).	-	(1) Toddlers' UE and AX movements confirmed previously developed MPs categories. (2) Age differences among toddlers regarding MPs. (3) MPs of UE and AX thought to occur earliest in the STS developmental sequence prevailed in this young group.
Mewasingh et al. (2002) [29]; Belgium	To analyze whether children with spastic diplegia use MPs as described for TD children and whether other MPs coexisted.	OBS/NP; 10 children with spastic diplegia associated with leukomalacia (♀ = 7; mean age = 7.5 ± 2 yrs.), CG: 14 age-matched TD children.	Process—MPs categories (UE, AX, and LE regions—adapted from Marsala and VanSant [12].	-	Children with spastic diplegia use MPs described in healthy children, but with markedly reduced within- and inter-individual variability.
Mewasingh et al. (2004) [30]; Belgium	To describe MPs in the STS task used by children with hemiplegic cerebral palsy (HCP).	OBS/NP; 15 children (♀ = 8; mean age = 7.3 ± 2.8) with HCP who were able to walk unsupported 5 m or more and perform the STS task without assistance; CG = 14 age-matched TD children.	Process—MPs categories (UE, AX, and LE regions, adapted from Marsala and VanSant [12]	-	Children with HCP performed the STS task using general MPs, but with reduced inter-individual variability compared to CG, with more asymmetrical patterns with systematic support on the unaffected side.

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
			Childhood		
Beenakker et al. (2005) [36]; Netherlands	To report typical values for timed functional tests in TD children; to determine which parameter changes most in ambulant children with DMD by comparing typical values for muscle force and functional ability with values obtained by these children.	OBS/NP; 16 ambulant children with DMD (mean age = 6.25 ± 0.93); TD children: ♂ = 66 (mean age = 7.4 ± 2.3) and ♀ = 57 (mean age = 7.4 ± 2.2 yrs.).	Product—STS time (s).	Running 9 m.	STS time in TD children: 4 yrs. (♀ = 1.52 s; ♂ = 1.56 s), 5 yrs. (♀ = 1.45 s; ♂ = 1.45 s), 6 yrs. (♀ = 1.17 s; ♂ = 1.42 s), 7 yrs. (♀ = 1.19 s; ♂ = 1.28 s), 8 yrs. (♀ = 1.03 s; ♂ = 1.24 s), 9 yrs. (♀ = 1.06 s; ♂ = 1.17 s), 10 yrs. (♀ = 1.42 s; ♂ = 1.08 s), and 11 yrs. (♀ = 1.13 s; ♂ = 0.99 s). The DMD children's performance declined with age, while TD children improved it; DMD children (8 yrs.) took 7.5 times longer than DD ones; timed functional testing seemed to be more sensitive to determine disease progression and functional impairment changes than force measurement.
Ng et al. (2013) [31]; UK	To define typical values from the time to STS and the time to run 10 m, formulate charts for these tests, and assess their reproducibility.	OBS/pre-longitudinal screening/NP; n = 321 TD children; ♀ = 160; age range = 2–8 yrs. (mean age = 5.1 yrs.).	Product—STS Time (s); Process—the method used to stand from the supine position.	Age, sex, height, weight, BMI, and time to run 10 m.	STS time = 2.08 s (range 1.03–5.28 s); an association between the standing method and age; boys: Association between the standing method and STS time; large variability in the method used and STS time in youngers; strong negative correlation with age; height, weight, or BMI not affected the STS time; charts showed age-related values.

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
			Childhood		
Kuwabara et al. (2013) [32]; Japan	To determine the relationship between the choices of movement patterns in STS task and physical functions in healthy children. O	68 TD children (♀ = 42), age range = 3.4–6.4 yrs.	Process—MPs categories (UE, AX, and LE regions, from VanSant [3]	Age, sex, grip strength, trunk flexor, and extensor strength; balance in one-leg standing time(s)	Children who demonstrated symmetrical MPs had significantly higher grip and trunk muscle strength and better balance than children who showed asymmetrical MPs. The symmetrical MPs were explained by a positive relationship to grip strength and trunk flexor strength. Muscle strength seems to be related to symmetrical MPs of the STS task in healthy children.
Hsue (2014) [21]; Taiwan	To determine the within—and inter-rater reliability in classifying the MPs of STS task in TD children and children with mild to moderate DD.	OBS/NP; 68 TD children: 5–6 yrs. (n = 15), 4–5 yrs. (n = 19), 3–4 yrs. (n = 20), and 2–3 yrs. (n = 14); 20 children with DD: 5–6 yrs. (n = 4), 4–5 yrs. (n = 4), 3–4 yrs. (n = 6), and 2–3 yrs. (n = 5).	Process—MPs categories (UE, AX, and LE regions)	Developmental capability tested by Peabody Developmental Motor Scale-II.	Complexities and difficulties affecting the within- and inter-rater reliability in classifying the MPs of STS task were related to developmental capability, age, and body region. Extra training seems to be needed for children with DD, particularly for the UE and LE regions.
Hsue (2014) [22]; Taiwan	(1) To determine MPs of children with DD used to STS task and how they differ from age-matched TD children, (2) to verify whether MPs differ with age in children with DD, and (3) To determine and compare the developmental sequences for the MPs for UE, AX, and LE in DD children and TD children.	OBS/NP; 66 TD children: 5–6 yrs. (n = 15), 4–5 yrs. (n = 19), 3–4 yrs. (n = 19), 2–3 yrs. (n = 13); 31 children with DD: 5–6 yrs. (n = 5), 4–5 yrs. (n = 6), 3–4 yrs. (n = 8), 2–3 yrs. (n = 12).	Process—MPs categories (UE, AX, and LE regions) from VanSant [3] revised by Marsala and VanSant [12], and Belt et al. [40]	Developmental capability tested by Peabody Developmental Motor Scale-II (	The TD group followed the proposed developmental sequences, as well as the DD group, which showed different maturation speed and more variability, especially between the age of 3 and 5 yrs.; the most used MPs by children with DD were at least one developmental categorical pattern behind those used by the age-matched TD children before 5 yrs. Old, except for the LE region. In the DD group, children with better motor performance used more developmentally advanced patterns.

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
			Childhood		
Duncan et al., (2017) [11]; UK	To examine how STS performance is related to process and product assessment of motor competence (MC) in children.	OBS/NP; 91 TD children (♀ = 44) aged 5–9 years (mean age = 6.8 ± 1.2 yrs.).	Product—STS Time (s) Process—MPs categories (UE, AX, and LE regions—VanSant [3].	MC score comprised four skills: run, jump, catch, throw, 10 m running speed, and standing long jump distance.	Children who scored higher on STS process also scored higher on MC process and were faster in the 10 m running time; a significant association between STS time and BMI (r = −0.508), STS time and STS process (r = −0.463), standing long jump distance (cm) and STS time (r = −0.414), and 10 m running speed (s) and STS time (r = 0.539). STS test is a measure of functional MC in children.
Nesbitt et al. (2017) [12]; US	To examine the relationship between qualitative (developmental sequences) and quantitative (time) performance rising from a supine position in early childhood.	OBS/NP; 122 TD children (♀ = 56); age range = 3–5 years (mean age = 4.63 ± 0.5 yrs.).	Product—STS Time (s) Process—MPs categories (UE, AX, and LE regions—VanSant [3].	BMI	The children' STS task performance was quite variable in terms of qualitative MPs; STS mean time = 2.37 s, ± 0.60. The levels of the components of UE (r = -.383) and AX (r = −416) were correlated with time. Results indicated a strong association between trunk control development and UE (r = 0.791) movement levels, and together they demonstrated the strongest effect on STS performance. There was no association between BMI and time in the STS task.

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
Childhood and Adulthood					
Belt et al. (2001) [42]; US	To determine if previously published descriptors of the STS task in healthy individuals could be applied to the movements of persons with Prader-Willi Syndrome; and 2) assess UE, AX, LE region movements among subjects with PWS compared with TD controls.	OBS/NP; 9 subjects (children and adults) with PWS and nine matched TD controls; age range = seven –36 yrs.	Process—MPs categories (UE, AX, and LE regions) were classified using modified descriptors developed by Marsala and VanSant [12]; Product—STS time (s)	BMI	Subjects with PWS utilized less advanced asymmetrical rising patterns, took longer to rise (5.4 s for subjects with PWS and 2.86 s for controls), and demonstrated less within-subject variability than controls. Knowledge of successful rising patterns may use to assess and plan intervention strategies. Regardless of diagnosis, there was a weak correlation between body region movement score and BMI (rho = 0.01). There was no relationship between BMI and body region scores.
Nesbitt et al. (2018); [8]; US	To examine the validity of STS as a developmental measure of functional MC across childhood into young adulthood and examining associations between movement components. STS time also provided a secondary measure of developmental validity in addition to an examination of the concurrent validity of STS against developmentally valid measures of MC.	OBS/NP; 265 subjects ♂♀(children and adults) distributed in 4 age groups: 3–6 (mean age 4.8 ± 0.9 years); 9–12 (mean age 10 ± 0.8 years); 13–17 (mean age 14.9 ± 0.9 years); 18–25 (mean age 20.9 ± 2 years)	Process—MPs categories (UE, AX, and LE regions) were classified using modified descriptors developed by Marsala and VanSant [12]; Product –STS time (s)	Developmentally valid measures of motor competence Throwing, kicking, jumping, hopping, and STS skills test	Results indicated that cross-sectional curves for the STS components generally fit Roberton's (1980) hypothetical model curves. STS time demonstrated weak to moderate correlations to STS time across all age groups, indicating that it can be considered a valid and reliable measure of MC across childhood into young adulthood

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
			Adulthood		
VanSant (1988b) [10]; US	(1) To describe MPs within specific body regions used to stand up from a supine position. (2) To identify motor developmental sequences for the UE, AX, and LE regions during this rising task.	OBS/NP; 32 healthy adults (♀ = 17); age range = 20–35 yrs. (mean age = 28.6 yrs.).	Process—MPs categories (UE, AX, and LE regions).	-	Subjects varied greatly in the MPs; 25% of subjects demonstrated a similar combination of MPs during rising, which involved the symmetrical use of the limbs and trunk while flexing forward from a supine position, moving through sitting to squatting, and then standing. An ordering of categories for each body region was proposed as a developmental sequence of STS MPs.
Green and Williams (1992) [14]; US	(1) To validate categories for the MPs of STS task in adults. (2) To evaluate the influence that physical activity might have on the MPs used for rising.	OBS/NP; 72 adults, age range = 30–39 years (mean age = 34.1 ± 2.8 yrs.) divided into three groups: group 1 (n = 25) reported daily physical activity, group 2 (n = 26) reported exercising once or twice a week, and group 3 (n = 21) reported did exercises less than once a week.	Process—MPs categories (UE, AX, and LE regions—VanSant, [3].	Level of physical activity (questionnaire).	More active people used more advanced MP than the rarely active ones. The lifestyle patterns of regular, moderate physical activity may influence the STS task performance. This study provided support for the use of developmental sequences for the MP of the STS task.
Didier et al. (1993) [43]; France	To compare the energetic costs of daily activities in young and older adults, such as rising and sitting back down on a seat, getting up from and lying down on a bed, and getting up from the floor.	OBS/NP; 10 healthy men (mean age = 24.3 ± 2.8 yrs.), and 10 older men (mean age = 74.4 ± 2.2 yrs.).	Product—STS time (s).	Energy Cost	Getting up from and lying down on the floor or a standard hospital bed involved the same energy cost in the older and younger group, but performing these activities took significantly longer for the older people

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
			Adulthood		
King and VanSant (1995) [41]; US	To verify if SAFOs affect the MPs used in the STS task, and to determine the mode and the incidence of MPs under each condition.	Interventional/NP convenience sample; 39 healthy adults, age range = 20–28 yrs. (mean age = 22.7 ± 1.87 yrs.).	Process—MPs categories (UE, AX, and LE regions).	-	Changes in the incidence of MPs occurred in all SAFO conditions, but not with the no SAFO condition. Changes resulted in more asymmetry in SAFOs condition, mainly in the axial region.
		Adulthood and Elderly phase			
Alexander et al. (1997) [4]; US	(1) To determine the ability of older adults to rise from the floor; (2) explore how the ability to rise might differ based on the initial body position, with and without the use of an assistive device.	OBS/NP; 24 (♀ = 12) adults, age range = 19–30 years (mean age = 23 yrs.); 24 (♀ = 12) healthy older adults, age range = 66–87 yrs. (mean age = 73 yrs.); 38 (♀ = 32) older adults, living in congregate housings for the elderly, age range = 63–94 yrs. (mean age = 80 yrs.).	Product—STS time (s); Process—from five different initial positions, with and without external support: (1) supine; (2) on the side; (3) prone; (4) all fours; and (5) sitting.	Perceived level of difficulty.	Older adults had more difficulty performing STS task than young. Healthy older adults took two times longer than adults to rise; congregate older adults took 2–3 times more than healthy older adults. Adults and healthy older adults rose from every position; Congregate older adults were most likely rising successfully from a side-lying position using furniture for support. The most capable subjects rose more quickly and had fewer difficulties when rising from the all-fours position.
Ulbrich et al. (2000) [44]; US	To describe how older adults, particularly more physically impaired older adults, might differ from healthy young adults in the body positions used to rise from the floor.	OBS/NP; 22 (♀ = 11) young adult controls, age range = 19–30 yrs. (mean age = 23 ± 3; yrs.), 24 (♀ = 12) healthy older adults, age range = 66–87 yrs. (mean age = 73 ± 6 yrs.), and 29 (♀ = 29) congregate housing older adults, age range = 63–94 yrs. (mean age = 81 ± 7 yrs.)	Product—STS time(s); Process—Intermediate Position (IP): sit, crouch, side-lying, tuck, half-tuck, kneel, half-kneel, crouch-kneel, all fours, bear walk.	-	Congregate residents were slowest in rising (17.1 s) and used the most IP, followed by healthy older adults (5.5 s) and young controls (2.6 s). The most preferred rise strategy used by controls was sat and crouch, whereas congregate residents used tuck, crouch-kneel, all fours, and bear walk; healthy older adults used IPs common to young adults and congregates

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
Adulthood and Elderly phase					
Bohannon and Lusardi (2004) [33]; US	(1) To explore the relationship between STS performance and age, functional lower extremity strength, and balance; and (2) to describe movement strategies used by healthy older adults when getting up from the floor.	OBS/NP; 52 (♀ = 38) healthy and independent community-living volunteers, age range = 50–90 yrs. (mean age = 64.6 ± 9.5 yrs.). There was a relatively equal distribution of participants across decades of ages within the sample.	Product—STS time (s); Process—three distinct stages: Initiation, transitional weight transfer, and going to upright posture, and there were some strategies in each stage.	Muscle strength: Time to complete five sit-to-stand cycles. Balance: Timed (s) single limb stance with eyes open (up to 30 s) both sides.	STS time = 4.1 ± 1.1 s, ranging from 1.8 to 7.2 s; Correlations: STS time and age, r = 0.48; STS time and sit and stand test, r = 0.64; STS time and single right stance, r = −0.36; STS and left single stance, r = −0.42; STS performance may be enhanced by training that addresses impairments in lower extremity strength and balance.
Schwickert et al. (2015) [23]; Germany	(1) To develop a model of MP sequences for unassisted STS task from different lying positions; (2) to identify differences in the MPs and transfer times of healthy older adults compared to healthy young adults, and identify difficulties in the MPs of older adults; and (3) to verify the associations with executive function, power, and flexibility.	OBS/NP; 14 (♀ = 7) young adults, age range = 19–39 yrs., and 10 (♀ = 5) older adults, age range = 59–79 yrs.	Product—STS time (s); Process—type and number of components to perform the STS task in a naturalistic scenario and a standardized scenario.	Trail making test; maximum gait speed 4 m distance, 30 s chair rise, Romberg test, Nottingham power rig, chair sit-and-reach test, goniometry.	Seven task components were noted: Lying, initiation, positioning, supporting, and elevation stabilization followed by quiet stance or walking; older adults = 5.7 s vs. young adults = 3.7 s ($p < 0.001$). There was a reduction in STS performance in older subjects, which was associated with reduced power and flexibility. Executive function, leg and hip power, and knee flexibility were lower in the older adult group. The scenario type did not influence the number of STS task components.

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
Adulthood and Elderly phase					
Schwickert et al. (2016) [45]; Germany	To analyze different kinematic features of standing up from the floor in adults and healthy older adults using inertial sensors describing such transfer patterns.	OBS/NP; 14 (♂ = 7) adults, age range = 20–50 yrs., and 10 (♂ = 5) healthy older community dwellers aged ≥60 yrs.	Product—Transfer time (s); transfer angular velocity; vertical velocity and acceleration; jerk Process—smoothness, fluency, and complexity of movement strategies.	-	The motion sequences of the older adults were less fluent and smooth than in the younger group; older subjects used more indirect movement strategies, including more turns around the longitudinal axis to prepare for elevation. There was the feasibility of describing and discriminating the performance kinematics of younger and older subjects standing up from the floor from different lying postures, using inertial sensor signals at the trunk.
Elderly					
Schenkman et al. [46] (2000); US	To determine (a) the associations between spinal flexibility and functional limitations; (b) the relative contribution of spinal flexibility to specific functional limitations; and (c) how disease state (PD vs. no PD) modified these relationships	OBS/NP; n total = 251; 56 older adults with PD (♀ = 24,5%) (mean age = 70.7 ± 7.4 yrs.); 195 non-PD (mean age = 71.4 ± 5.0 yrs.)	Product—STS time (s);	Spinal flexibility; functional reach distance; 10-m walk time; number of steps to turn 360°	PD older adults, STS time = 7.2 ± 3.7; non-PD older adults, STS time = 5.2 ± 2.0. Spinal flexibility was a significant predictor of supine-to-stand time and the number of steps in the 360 degrees turn, but there was no clinical significance for these two variables
Bergland et al. (2002) [15]; Norway	To evaluate the concurrent and prospective validity of self-reported items concerning walking and balance.	OBS/Probabilistic, longitudinal, and predictive; 307 elderly women, living at home, age range = 75–93 yrs. (mean age = 80.8 yrs.).	Product—scored according to whether the subject managed to perform the STS task without assistance (1 point) or not (0 points).	Tandem stance/eyes open; functional reach; one-legged stance/eyes open; walking in figure-eight; climbing stairs; self-reported walking difficulties.	About 80% of the women managed to perform the STS task and could cope with steps higher than 30 cm; younger subjects performed better than those in the higher age bands in all tests; all clinical tests correlated significantly with each other (range = 0.25–0.85) and also with the self-reported walking index (range = 0.32–0.62).

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
Elderly					
Hofmeyer et al. (2002) [20]; US	To determine the effect of a 2-week training intervention to improve disabled older adults' ability to rise from the floor.	Interventional/Random allocation; healthy older adults. Training group (n = 17, ♀ = 13; mean age = 81 ± 6 yrs.) submitted to an individual training in strategies to rise from the floor using key body positions; control group (n = 18, ♀ = 13; mean age = 80 ± 7 yrs.) submitted to an chair-based flexibility intervention.	Product 1—able or not able to perform the STS task in eight different conditions; Product 2—STS time.	The Perceived Scale of Symptoms and Difficulties.	The training group showed a significant improvement in the post-test mean number of rising tasks completed; regarding the supine position, the mean rise time varied from 21–25 s at baseline to 20–27 s post-intervention, but such improvement was not significant. The training group showed a significant improvement in the level of difficulties and symptoms.
Bergland et al. (2004) [16]; Norway	To verify whether balance, function, and other health status indicators can predict serious fall-related injuries or fall-induced fractures in older women.	OBS/Probabilistic, longitudinal, and predictive; 307 women, age range = 75–93 yrs. (mean age = 80.8 yrs.) who were living at home.	Product—scored whether the subject managed to perform the tasks without assistance (1 point) or not (0 points).	Other measures: Serious fall injuries over a year, health records, function, and walking and balance	Rheumatic disorders and the inability to perform STS task were the most substantial independent risk factors for fall-related severe injuries.
Henwood et al. (2005) [47]; Australia	To investigate the effects of a short-term high-velocity varied resistance training program on physical performance in healthy community-dwelling older adults aged 60 to 80 years.	Interventional/NP; 25 healthy community-dwelling men and women, age range = 60–80 yrs.; they were divided in two groups: Experimental (n = 14; 69.9 ± 6.5 yrs.) and control group (n = 10; 71.3 ± 5.6 yrs.).	Product—STS time (s).	Muscle power and strength measures: Chair rise to standing, 6-m walk, lift and reach; BMI and percentage of body fat.	In Baseline, Experimental group STS time = 4.5 ± 0.8 s; control group STS time = 3.8 ± 0.9 s; after training there was 10.4% reduction in time in the experimental group from the baseline (p = 0.006). There was a group X time interaction for floor rise to standing (experimental group). There was no change in body composition during the study.
Bergland et al. (2005) [17]; Norway	To assess the concurrent and predictive validity of older women's ability to get up from lying on the floor.	OBS/Probabilistic; predictive; 307 elderly women, age range = 75–93 yrs. (mean age = 80.8 yrs.) who were living at home.	Product—scored whether the subject managed to perform the tasks without assistance (1 point) or not (0 points).	Falls and falls-related injuries, function measures, and health and social resources.	The STS task is a valid marker of failing health and function in older adults and a significant predictor of serious fall-related injuries.

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
			Elderly		
Manini et al. (2006) [40]; US	Develop a task modification scale to examine its reliability and comparability to timed performance and standard measures of physical function and impairment in older adults	OBS/NP; 82 (♀ = 21) older adults (mean age = 74.4 ± 8.2 yrs.)	Product—STS timeProcess—MOD Score	Gait speed (fast and regular), five chair rises, self-reported physical function, knee extensor strength, and single-leg balance.	The MOD score is reliable across raters and repeatable within participants; also, it showed higher correlations with muscle strength and balance impairment than did other measures as gait speed, time to complete five chair stands, and self-reported physical function.
Mankoundia et al. (2007) [48]; France	To determine whether the management, including medical, psychological and physiotherapeutic approaches may be beneficial in the short and medium-term, for elderly fallers with psychomotor disadaptation syndrome.	Interventional/NP; longitudinal; 28 (♀ = 25) elderly fallers (mean age = 81.43 ± 6.7 yrs.).	Product—STS time (s)	Functional Independence Measure, Mini Mental State Examination, Tinetti test, Mini Motor test, Dual Task test, Beck Depression Inventory-II, Covi Scale, Modified-Falls Efficacy Scale	The multidisciplinary intervention had an overall positive impact on motor abilities as shown by the increase in the mini-motor test scores, the rate of success in rising from the floor and decrease of time for the dual task.
Manckoundia et al. (2008) [38]; France	Identifying the demographic and clinical parameters, assessed during a standard health examination, affects balance control in older adults.	OBS/NP; 2368 (♀ = 1215) older adults (mean age = 70.0 ± 4.5 yrs.).	Product—able or unable to perform the STS task.	Age, gender, BMI, cognitive status, self-perception of health, and use of psychotropic drugs	Women (8%) failed more than men (2.7%) in the STS task. Women who failed in the STS task had higher diastolic blood pressure and glycemia; BMI and health scores determined errors in the STS task in both genders. The BMI was a significant determinant of performance in all balance tests.

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	**Lifestyle/Motor Functions**	
			Elderly		
Geraldes et al. (2008) [49]; Brazil	To investigate the relationship between flexibility of flexion and extension of the glenohumeral and coxofemoral joints and functional performance among physically active and functionally independent elderly women.	OBS/NP/22 functionally independent elderly women mean (age 70 ± 6 yrs)	Product-STS time (s).	Flexibility of the glenohumeral and hip joints	There was a significant association between assisted-active flexibility and STS performance.
Naugle et al. (2012) [37]; US	To examine the association between compensatory strategies to successfully daily activities and body mass in pre-clinically disabled older adults.	OBS/NP; 259 (♀ = 116) older adults (mean age = 67.6 ± 7.0 yrs).	Process—MOD Score evaluated (0 to 5 points) participants' performance on each task according to the severity of the compensatory strategy to complete the task.	Chair rise from three heights (43, 38, and 30 cm), kneel to stand, stair ascent, stair descent, and lift and carry a basket filled with 10% of the subject's BMI.	The obese class II group had a higher likelihood of using one or more compensatory strategies while performing the STS task compared to all other groups. Individuals categorized as overweight and obese Class-I were more likely to use compensatory strategies while performing the STS task than the healthy weight group.
Raso and Greve (2012) [50]; Brazil	To determine the effect of an aerobic or resistance exercise protocol on the performance of daily living activities in older women.	Interventional/NP/random allocation; 41 healthy elderly women, age range = 60–85 yrs. (mean age = 65.1 ± 7.9 yrs.) randomly assigned to resistance (n = 22) or aerobic exercise (n = 19).	Product—STS velocity (s).	Performance in these tasks was measured while subjects were wearing sneakers: Sitting to standing position, STS task, and climbing stairs.	Subjects of the aerobic exercise protocol improved speed significantly when wearing sneakers, while subjects of the resistance exercise protocol improved their performance in the STS task and climbing stairs when using these shoes.

Table 1. *Cont.*

Author (Year); Country	Objective	Study Design/Sample Characteristics	Main Outcome Measures		Main Results and Conclusions Related to STS Task
			Process or Product-Oriented Movement	Lifestyle/Motor Functions	
			Elderly		
Klima et al. (2016) [39]; US	To examine physical performance correlates of timed supine to standing performance, Furthermore, to identify the predominant motor pattern used to complete rising from the floor.	OBS/NP; 53 (♀ = 36) older adults (mean age = 78.5 ± 8.5 yrs.).	Product—STS time (s); Process (symmetrical rise and squat sequence or symmetrical rise and asymmetrical squat sequence or roll and push maneuver).	Handgrip, balance, 9-m walk test, TUG test; Physical Activity Scale for Elderly	STS time was associated with age (r = 0.57), gait velocity (r = −0.61), ABC scores (r = −0.51); there were correlations with physical activity (Rho = −0.29), grip strength (r = −0.30); and with the TUG test (r = 0.71). Hierarchical regression demonstrated that TUG performance predicted 48% of the variance in STS time (p < 0.001). This significance remained after adjusting for age and BMI covariates.
Manckoundia et al. (2020) [51]; France	To investigate the impact of an ambulatory physical activity program on the motor skills of retirees	Interventional, not controlled study/NP. N total = 200 living home healthy older adults (♀ = 172), age range = 60–100 yrs. (mean age = 73.8 ± 7.4 yrs.). They were divided into two groups for STS task: Robust subjects vs. frail or very frail subjects. The program included strengthening muscular and joint flexibility exercises, balance work, one-leg-balance test, stimulation of the foot arch, STS task, TUG, gait speed, one-leg-balance	Product—able or unable to perform the STS task.	One-leg-balance test, TUG, gait speed, one-leg-balance test duration	For STS, 81% of participants did not change groups after training program, 18.5% changed from (very) frail to robust, and 0.5% of subjects changed from robust to (very) frail.
Moffett et al. (2020) [52]; US	To describe the performance and clinimetric properties STS completed by apparently healthy community- dwelling older women	OBS/methodological quality study; 52 ♀(mean age = 66.4 ± 8.1 yrs)	Product—STS time (s)	36-Short Form Health Survey, Gait Speed test, Sit-To-Stand test, Johns Hopkins Fall Risk Assessment	STS test appears to be informative, valid, and reliable, at least for older independent women.

♀ = female; ♂ = male; AX—Axial region; BMI—Body Mass Index; CG—Group control; DD—Development delay; DMD—Duchenne muscular dystrophy; DS—Developmental sequence; HPC—Hemiplegic cerebral palsy; IP—Intermediate Positions; LE—Lower extremity; MCR—Medical Council Research scale; mo.—months; MOD Score—score representing task modifications; MPs—Movement Patterns; NP—non-probabilistic; OBS—observational study; PD—Parkinson's disease; PWS—Prader-Willi Syndrome; SAFOs—Solid ankle-foot orthoses; STS task—Supine to Stand task; STS Time (s)—Time needed to complete the STS task in seconds; TD—Typical development; TUG—Timed Up and Go test; UP—Upper extremity; yrs.—years. Source: the authors.

Just four studies reported the verbal instructions on starting position, which included legs extended and arms extended to the side of the trunk [14,31,36,40] five studies reported the final position as stable standing upright with both feet on the ground [23,24,31,38,40]. Nesbitt et al. [8] used final position goal combined with touching a designated point on the wall; Alexander et al. [4] asked the subjects to press a switch placed on a tripod when assuming the standing position, marking the end of the task. Other protocols' characteristics were summarized in Table 2.

None of the studies that investigated the STS task were classified as high risk of bias. However, the item most frequently absent in assessing the risk of bias was "Was the justification for the sample size?", with only 18.9% of studies presenting such a justification (for detailed information, see Supplementary Material Table S1).

Table 2. Absolute and relative frequencies of the protocols' characteristics of studies reviewed about the Supine-to-Stand (STS) task (*n* = 37).

		N	*f* (%)
Quality of study	Superior–Low risk of bias (≥ 12)	18	64.9
	Medium–Moderate risk of bias (8 to 11)	13	35.1
	Inferior–High risk of bias (≤ 7)	0	0.00
Number of trials *	Only one trial	7	18.9
	2 to 5 trials	12	32.4
	6 to 10 trials	10	27.0
	Above 10 trials	2	5.4
Instruction for performance speed	"As fast as possible"	18	48.6
	Comfortable speed	14	37.8
	Not informed	4	10.8
Participant's caring *	Use of the test trail	32	86.5
	Rest interval	11	29.7
	Demonstration	6	16.2
	Use of the assistants	6	16.2
Motivational strategies *	Feedbacks	3	8.1
	Rewards	1	2.7

* Not all studies have described these procedures. The table was originally created by the authors.

The STS Task Performance and Body Weight Status, Musculoskeletal Fitness and Physical Activity

By investigating young children, Ng et al. [31] and Nesbit et al. [12] did not find an association between STS time and BMI; by investigating older children, Duncan et al. [11] found a moderate inverse correlation ($r = -0.508$). Naugle et al. [37] investigated older adults and found that each unit of BMI was associated with an increase in the severity of compensatory strategies to rise; also investigating older people, Manckoundia et al. [38] found that being overweight was associated with fails to perform STS (not able to rise); Henwood and Taaffe [47] investigated the effect of a fitness program in seniors and found a positive effect on STS time. Belt et al. [42] investigated people from ages 7 to 36 years with Prader-Willi syndrome and typical controls, and regardless of diagnosis, they found a very poor correlation between STS task process measurement and BMI, but there were not confirmed relationships between BMI and any of the three body region scores. However, some cautions are need because BMI at different ages is related to various components of body composition.

Four studies investigated the relationship between STS task performance and musculoskeletal fitness, which showed a direct relationship [23,32,33,39]. One investigated children by testing grip and trunk muscle strength [32]; lower limb power of the older people were investigated [23,33,37,39], as well as flexibility [23] and upper limb strength [39]. One study [20] investigated a musculoskeletal training intervention on STS time performance in seniors that showed a positive effect.

Two studies examined the association between STS task performance with physical activity [14,39]. Green and Williams [14] investigated 72 middle-age adults and noted that the most active adults used more advanced STS task patterns than those who were rarely active, but they did not perform an inferential test. Klima et al. [39] investigated older adults and found an inverse correlation between STS task time and physical activity level (rho = −0.29).

4. Discussion

In this present review, the methods used in the STS assessment were summarized and critically examined. Furthermore, this review verified the association of STS task performance with select health variables. The results showed that the STS task performance was investigated throughout the life cycle, in various countries, and several studies used large samples [3,12,15–17,31,36–38]. In general, these results suggest the STS task can be considered a functional health assessment, from youth to old age.

However, the measurement type can be a critical issue. For example, by using a dichotomous variable (to be able or not gets up from the floor), Bergland et al. [15–17] investigated seniors (over 75 years) and concluded that the STS task is a valid marker of health and function problems, as well as a significant predictor of falls-related severe injuries in this life phase. One's ability to stand up is a validated measure; however [15], it does not reveal the phenomenon of functional MC throughout life, since it seems to have been very suitable for use in the sample of older subjects, but it must have a ceiling effect at younger ones.

Both process and product-oriented measurements were used in a similar proportion in the literature. Process-oriented measurement identifies the difficulties in the task but demands much time to code and seems to be more valuable to propose intervention, mainly in older adults. Alternatively, product-oriented measurement, as movement time, maybe more related to functional outcomes. Facing a challenge, such as standing up as fast as possible, and relating this outcome to functional capabilities, like muscular strength and endurance, speaks to the ability to solve a functional motor task in various ways and at various speeds. This task speaks to the importance of being able to vary the execution of STS based on specific task demands. Thus, STS time is a resourceful way to operationalize functional MC, mainly with large samples or studies with many variables, as it requires limited technological resources and provides better discrimination and sensitivity in measurement than process-oriented assessments.

4.1. Risk of Bias and Procedure Protocols

Since all studies showed a moderate or low risk of bias, the internal validity was considered satisfactory. The more comprehensive analysis of the STS protocols showed a wide variety of procedures, which can be a severe problem if one proposes to have one protocol to be used for all the developmental levels. The instruction on the mechanics of the movement can facilitate performance [34,35] so for an understanding of how people typically get off the ground, controlling the instructions is critical to STS assessment. All studies instructed subjects individually, and most of them relied on verbal information rather than demonstration; some researchers even explicitly prevented any visual demonstration or explanation of the STS mechanics [11]. In summary, it was clear that researchers avoided any modeling or verbal instruction bias to examine the movement patterns typically used by participants.

Also, the time constraint instruction needs to be highlighted, since maximum speed instruction can affect the automaticity of the movements (i.e., minimizing the conscious analysis of the motor action) [53]. An external focus of attention (i.e., time restriction) organizes the motor system according to individual constraints and choice, rather than when the focus of attention is internal (i.e., on a movement pattern), which can interfere with the automatic process control as explained by the "constrained-action hypothesis" [35,53]. Depending on the measurement intents, a researcher can choose whether to impose a time constraint. For instance, to examine a general STS movement process that individuals would use in everyday life, a time constraint would not be necessary. Alternatively, to examine functional capacity as it relates to a "best" or "maximal" performance, a time constraint may be the most appropriate option. The time factor may be a more salient choice to predict health outcomes as the ability to produce power has strong implications for all-cause mortality and functional independence in older adults [54], as well as fitness, physical activity, and weight status in youth and young adults [5,55,56].

The final position of the task is another critical element related to the instructions. Two studies combined the goal of postural alignment with an external target [4,12]. This seems to be an efficient methodological strategy, since the performer has a simple and easy-to-execute external goal (touching the point in front of him/her), and in turn, the evaluators' job is facilitated to stop the chronometer or video frame. However, understanding whether providing a final position with an additional reaching task might alter how an individual stand needs to be addressed.

Regarding feedback and rewards, three studies detailed the procedures given to motivate children by using verbal reinforcement during or after the task execution, using praise or words highlighting their efforts [3,12,24]. Motivational feedback was used only with early childhood children, since the motivational climate can dramatically affect preschoolers' performance [55]. Encouraging may be highly beneficial if the time task constraint is "maximum" (i.e., shortest time) [40].

The number of repetitions varied widely among the studies. This lack of uniformity weakens the findings as a high number of repetitions without adequate rest can cause fatigue, adversely affecting motor performance. It seems to be the case with older or frail individuals that demonstrate limited physical function and fitness. Conversely, only one trial may not represent typical behavior. When addressing the movement process, two to five trials would be necessary to gain insight into an individual's most probable movement process.

4.2. STS Performance and Body Weight Status, Musculoskeletal Fitness, and Physical Activity

Seven studies examined the body weight status and the STS task performance, and three of them demonstrating significant associations. It seems reasonable to expect that weight status, specifically with increased adipose tissue, is associated with STS performance. In overweight or obese individuals, the motor system has to overcome higher inertia to accelerate the body mass against the force of gravity to attain an upright position. Individuals can accomplish these using variable body actions that may not require high power outputs. Rather, maximizing postural alignments that minimize the demand for high muscle activity levels (i.e., manipulation of multiple degrees of freedom with minimum energy expenditure) would be a favorable strategy for individuals who demonstrate low muscular power/strength and endurance. However, while these strategies may be useful for minimizing energy expenditure, they may increase the time to stand. This potential trade-off may also speak to the variability in individuals' MC. If individuals demonstrate higher MC levels, they may be able to stand using different coordination patterns regardless of energy used (i.e., level of neuromuscular demand or segmental coordination patterns), as demonstrated in Didier's study [43]. However, individuals with low levels of overall MC may be more restricted in their movement patterns, due to a lack of muscular strength or coordinative capabilities across multiple joints. It is possible to think that the bodyweight status is a good candidate to be a moderator variable to the STS task performance, playing a role integrated with other fitness variables. More scientific pieces of evidence are necessary on this topic.

This review has confirmed there is a positive association between the STS task performance and musculoskeletal fitness for all ages, confirming previous literature results [5,6,55]. Therefore, it seems the STS is a good candidate to be a musculoskeletal health indicator in all cycle life.

The association between STS task performance and physical activity was examined in only two studies [14,39]. Even though the results had agreed with each other, and both studies have shown a low risk of bias, they have used different approaches, and one of them [14] did not report inferential associations. Thus, it seems too early to state that there is evidence of a direct association between physical activity and STS task performance. A previous study [56] has supported the notion of reciprocal action between the physical activity and MC, and perhaps it was the case of thinking more about how they enhance each other than just the simple relationship between them.

4.3. Clinical Applications

Hofmeyer et al. [20] carried out the only study that tested training for getting off the ground: Their results showed an improvement in the experimental group performance compared to the controls. This study reinforces that the STS task also has interventional value to health professionals. By taking all results of this review, one can generally state that STS is a potentially useful tool to examine functional MC and a general health status marker, as well as a useful approach to clinicians and researchers. It is notable in the present review that the STS task was investigated in the stages of childhood, adulthood, and old age. These results allow us to recognize that this is a task that is appropriate to play at all ages; in particular, a measure of the STS time has shown to have sufficient variability to distinguish individuals in all ages, without having a ceiling or floor effects.

The upright posture enables the subject to dominate his environment, and righting behaviors is an expression of physical independence [1]. Also, achieving such an upright posture in the shortest possible time, challenging individual constraints (e.g., unfavorable weight status), is a clear expression of human motor competence, i.e., the ability to solve motor problems in the face of challenging demands from the environment or of the subject itself. However, more evidence across the lifespan is needed to demonstrate these linkages.

Even the results of this review allow affirming that the STS task has a strong potential to uncover MC at any phase of life, the studies used diversified protocols and methodological strategies along with what prevented comparison and the generalization of findings. So, as a by-product of this review, a unique and universal protocol is proposed (Appendix A). We also understand that we are in agreement with contemporary literature on this subject. A very recent article [52] researched the same task with minor differences, showing its importance for older adults and investigating its clinimetric properties. We reinforce and extend the results of this study because we proposed that this task can be tested for all ages.

4.4. Study Strengths and Limitations

The strength of this study was that it examined all STS literature across the lifespan, and disentangled the various methods used to assess this task in several countries. It is plausible to present STS as a good candidate for a valid and non-culturally biased measure of functional MC across the lifespan. It is also advantageous to have a unique protocol that can be applied across all ages to facilitate tracking motor competence over time. The limitations of this study were that only studies in English were reviewed. Moreover, since the objective of this study was only to review methods, other studies should be carried out to establish typical values and significant cutoff points for the STS task performance.

5. Conclusions

This review showed that the STS task was tested at all ages, in various parts of the world, confirming it as a useful tool to track functional motor competence throughout life, in a universal way. In particular, measuring the time of the STS task is an ingenious way to operationalize functional motor competence mainly in large-scale studies. In addition, as it was found that the STS task has a strong relationship with musculoskeletal fitness over the years, it can help to monitor this health variable throughout life. It is not yet possible to recognize a factual relationship between the performance of the STS task and health variables, such as body weight status and physical activity.

Supplementary Materials: The following are available online at http://www.mdpi.com/1660-4601/17/16/5794/s1, Table S1 Risk of bias within articles included in the review regarding the performance of the supine-to-stand (STS) task.

Author Contributions: Conceptualization, M.T.C., F.S.d.S. and M.P.S.; methodology, M.T.C., F.S.d.S. and M.P.S.; formal analysis, M.T.C. and F.S.d.S.; investigation, M.T.C. and F.S.d.S.; resources, M.P.S., data curation, M.T.C.; writing—original draft preparation, M.T.C. and F.S.d.S.; writing—review and editing M.P.S., A.H.N.R., D.R.N., A.B.D.S., A.H.P.F. and D.F.S.; visualization, A.H.N.R., D.R.N., A.B.D.S., A.H.P.F. and D.F.S.; supervision, D.F.S.; project administration, M.T.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Box A1. Supine-To-Stand (STS) task measure protocol for all ages.

Objective: To get up as fast as possible from the floor.

Place and procedures

1. Quiet room with a clean and flat floor;
2. Floor marks. With a contrasting colored adhesive tape mark on the floor a perpendicular distance equal to the participant's arm length to the wall; this distance cannot be less than 30 cm, approximately the same distance of the semi-extend arms to the wall, in order to be a comfortable space to the participant rising him/herself.
3. Mark a dot on the wall. The placement of the target on the wall must match with the height of the subject's gaze.
4. Initial position: Lie flat (dorsal decubitus position) on the ground with hands in a prone position;
5. Final position: Upright orthostatic position touching a fixed target on the wall.

General recommendations

- ✓ The participant's feet must be bare, and it is suggested that participants wear light clothes, suitable for exercise;
- ✓ The subject makes a trail test in order to train before performing valid attempts.
- ✓ All commands given to participants must be communicated with kindness and firmness;
- ✓ Do not give any feedback to participants between tests;
- ✓ Do not give any visual instructions;
- ✓ Repeat a minimum of three times and more if needed to address process-oriented mode sequences; the best performance (lowest movement time) is the primary measure for the analyses;
- ✓ The interval between trials must last for as long as it takes for the participant to reposition himself/herself on the floor. It is not a problem if the participant takes more time between one attempt and another to return to the initial position: Individual comfort should be maintained;
- ✓ In the case of elderly participants, at least one assistant must be behind the performer to provide any help during the action of rising from the ground.

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International Journal of
Environmental Research and Public Health

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Does Motivation in Physical Education Have an Impact on Out-of-School Physical Activity over Time? A Longitudinal Approach

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Received: 31 August 2020; Accepted: 1 October 2020; Published: 4 October 2020

Abstract: Previous research based on the trans-contextual model proposes that autonomous motivation in physical education (PE) is transferable to an out-of-school leisure-time (LT) context. However, only cross-sectional and unidirectional analyses have been conducted. The present study used a longitudinal design assessing $N = 1681$ students ($M = 14.68$ years) on two occasions, measuring the following constructs: perceived need for support in PE, motivational regulation during PE and LT, attitude, subjective norm, perceived behavioral control, intention, and physical activity behavior. Findings based on mixed effect models revealed that autonomy, competence, and relatedness support of the PE teacher were positively related to autonomous motivation. Moreover, similar motivational regulation types were found to significantly cross-lag across contexts. Through longitudinal mediation analyses, further support for the impact of autonomous motivation on physical activity, mediated by intention, attitude, and perceived behavioral control, was found. Suggestions for educational stakeholders regarding how to promote students' autonomous motivation are provided.

Keywords: self-determination theory; physical activity; physical education; trans-contextual education; longitudinal design

1. Introduction

Physical education (PE) holds a unique and advantageous position in being able to address a significant number of children and adolescents. This, in turn, highlights its importance to promote competencies in school that will be beneficial to and implemented by the students also in their everyday life. Generally, one of the main components to ensure learning, or the intention to act, is one's inner motivation to do so [1,2]. In their multi-theoretical trans-contextual model, Hagger, Chatzisarantis, Culverhouse, and Biddle [3] postulate that the promotion of autonomous motivation in classrooms persists towards similar activities in contexts outside the school. Thus, students' autonomous motivation towards activities generated during PE may be transferred towards similar activities outside the classroom, such as physical activities in their leisure-time (LT). This trans-contextual transfer is highly important, especially when considering the overall continuing decrease in physical activity among youth [4].

More specifically, in their trans-contextual model, the authors propose three assumptions: (1) if the students perceive their PE teacher as need-supportive, this will positively influence their autonomous motivation, (2) autonomous motivation in PE will positively influence the students' autonomous motivation in an out-of-school context, and (3) autonomous motivation in an out-of-school context predicts future intentions to engage in out-of-school physical activities. In general, results of previous studies support these assumptions [5,6]. However, these studies tested the trans-contextual model only by means of correlative analyses, without considering the predicted causal directions. Therefore, the overarching aim of this study is to test these assumptions in a longitudinal design. In the following sections, the three assumptions of the trans-contextual model will be discussed in detail, as well as the resulting research questions for the present study.

1.1. Assumption 1: The Students' Perceived Basic Needs Support by the Teacher Influences the Students' Motivation in PE

The self-determination theory (SDT), a macro theory of human motivation [7], does not treat motivation as a unitary concept but differentiates between several types of motivation on a continuum, with the most central distinction being made between intrinsic and extrinsic motivation. Unlike different perspectives seeing extrinsic motivation as invariantly non-autonomous, SDT proposes that extrinsic motivation can greatly vary in its level of autonomy [8]. In this sense, SDT defines three types of autonomous motivation. Firstly, *intrinsic motivation* refers to the most autonomous form of the continuum and reflects the engagement in an activity for the inherent satisfaction of the activity itself, because doing so leads to experience ownership over one's actions and consistency between one's behavior and authentic self. Intrinsic motivation is the only behavioral regulation type, which is performed in the absence of any external contingency. Secondly, another type of autonomous motivation is *identified regulation*. Identification reflects a conscious valuing of a behavioral goal or regulation, such that the individual is engaging in activities because they serve self-endorsed outcomes and are personally important. The third type of autonomous regulation, which reflects the most autonomous form of extrinsic motivation, is *integrated regulation*. Integration occurs when identified regulations are fully assimilated to the self, which means that integrated regulated actions are perceived to be entirely consistent with self-endorsed values and needs. Actions characterized by integrated motivation share many qualities with intrinsic motivation, although they are still considered extrinsic because they are performed to attain separable outcomes rather than for their inherent enjoyment [8]. In contrast to autonomous motivation, two controlled types of motivation are proposed by SDT, which reflect behavioral engagement for reasons of more externally regulated motivators, such as obligation or reinforcement. The first extrinsically motivated and least autonomously motivated behavior is *external regulation*, which reflects behaviors that are performed to satisfy an external demand in order to receive a reward or avoid punishment. The reason to engage in the behavior is perceived as controlled and inconsistent with the individual's authentic sense of self. Lastly, *introjected regulation* involves taking in a regulation to the self but not fully accepting it as one's own. This is a relatively controlled form of regulation, in which behaviors are performed to avoid guilt or to promote contingent self-worth. Even though introjected regulated actions are driven by the individual itself, they represent experiences as other-endorsed rather than as a part of the self. Both intrinsic and extrinsic motivation presuppose that an individual is motivated in the first place. In this sense, and in contrast to these motivation types, SDT defines *amotivation* as a state of lacking any intention to act.

The theoretical assumptions of SDT have been applied to a wide range of life domains. A more autonomously regulated form of motivation is considered to be associated with the persistence of self-determined learning and behavioral activities, and was found to be related to various positive outcomes. These outcomes range from academic attainment, performance, knowledge, psychological wellbeing, and happiness to the intention to become physically active [9–12], and, thus, represent a particularly important factor in education.

As a substantial basis for energizing and directing action from a controlled towards an autonomous motivation, Deci and Ryan [13] use the concept of three innate psychological needs for autonomy (sense of control of own behavior), relatedness (feeling connected with significant others), and competence (feeling of being able to carry out a behavior). With regard to PE, previous studies suggest that teachers, who act in a need-supportive manner, facilitate students' need satisfaction and, thus, generate motivation that is more autonomous and, hence, internally motivated [5,14,15].

Interestingly, previous research has primarily focused on the promotion of the support of autonomy [16]. As the satisfaction of all three needs in SDT [13] is described as innate and fundamental for intrinsic motivation, we assume that, consequently, the support of all three different basic needs will positively affect the students' autonomous motivation. This is why, in the present study, the students' perceived support of all three basic needs by the PE teacher will be analyzed over time in order to study their distinct influence on intrinsic motivation and identified regulation. For instance, providing choice for the students in class (autonomy support), encouraging students to set realistic goals (competence support), and creating a climate where students are encouraged to interact with the teacher and classmates (relatedness support) should promote self-determined motivation in class. Furthermore, as contextual motivation is a dynamic process, changes over time are very likely to occur [17]. By employing a mixed effects model approach, we are able to analyze continuous responses in our longitudinal design in order to analyze the proposed relations via a robust method controlling for fixed and random effects [18].

1.2. Assumption 2: School-Related PE Motivation Persists in an Out-of-School (LT) Context

The second main goal of this study is to uncover larger persisting effects of motivational regulation types beyond the school context (i.e., towards an out-of-school context, e.g., physical activity during LT) [6]. This transfer of the motivational regulation from one context towards another has been discussed in two theoretical approaches. First, continuing motivation [19] is defined as the tendency to return to and continue working on tasks away from the instructional context. For instance, children may learn the relevant techniques of playing a particular sport in class, but becoming a good player requires them to continue practicing without instructions over and above that, namely, also in an out-of-school context [19]. Second, the hierarchical model of intrinsic and extrinsic motivation [20] postulates that different motivational types should be inter-correlated or, in other words, persist over contexts. Hagger and colleagues [3] describe this inter-correlation between contexts in their trans-contextual model, using the transfer of motivation from a school context towards an out-of-school context as showcase. In their meta-analytic path analysis, Hagger and Chatzisarantis [6] found a significant and large positive relation between autonomous motivation during PE and autonomous motivation of physical activity during LT. This finding is important insofar as a successful promotion of autonomous motivation in schools might persist in an out of-school context, which is crucial for continuing self-determined regulation of behavior [21].

As earlier research focused on cross-sectional path analyses to test the assumptions of the trans-contextual model, in this study, we want to analyze the often criticized proposed unidirectional paths in a longitudinal setting [22]. Based on Vallerands' hierarchical model [20], we assume that, beyond the assumptions of Hagger and colleagues [3], not only similar motivation types in PE will be associated with LT over time, but that also similar motivation types in LT will influence similar motivation types in PE. In other words, we suspect that the promotion of autonomous motivation in class affects autonomous motivation in out-of-school physical activities, and vice versa. Although controlled types of motivation and amotivation are significant factors present in PE and LT, as, for example, repetitive and boring exercises might very probably be experienced in both school and LT, we assume that also controlled types of motivation and amotivation will be intercorrelated over time and context. Thus, in the present study, we hypothesize that all five types of motivational regulation measured in this study (i.e., amotivation, external regulation, introjected regulation, identified regulation, and intrinsic motivation) positively influence their counterparts across PE and LT, and might exert a negative influence on motivation types from the other end of the continuum (e.g., intrinsic motivation in LT might be negatively related to external regulation in PE over time). In order to analyze these proposed relationships, a cross-lagged panel model is employed [22].

1.3. Assumption 3: Motivation in LT Influences Physical Activity Behavior in LT

Finally, as the promotion of autonomous motivation in PE should persist in LT, the question whether autonomous motivation in LT has an impact on actual physical activity behavior in LT remains unanswered. However, answering this question becomes crucial when considering that only one third of adolescents from 146 countries reach the World Health Organization (WHO) guidelines of being physically active for at least 60 minutes a day [4]. In their trans-contextual model, Hagger and colleagues [3] refer to the theory of planned behavior (TPB) [23] in order to analyze and understand volitional and intentional behavior. According to the TPB, an individual's intention towards a specific behavior is the strongest predictor of behavior. Intention is proposed to be mediated by the attitudes towards the specific behavior, the subjective norms (pressure placed by significant others towards the behavior), and the perceived behavioral control (one's own capability to do it). In turn, perceived behavioral control is envisaged to have a direct effect on behavior. Even though this social-cognitive model successfully explains a substantial proportion of variance in physical activity intentions and behavior in studies with adolescents [24], the model does not consider global, goal-related motives, which may act as sources of information in the formation of intentions [25]. In order to expand the question of "what", as addressed in social-cognitive frameworks, the SDT was found to be adaptable in implementing the question of "why" individuals form intentions, attitudes, subjective norms, and perceptions of their behavioral control. Recent studies provided support for the influence of the different motivational regulation types (generalized motives) towards the situation-specific decision-making variables and found substantial evidence to combine the two theoretical models [25].

The third aim of the present study is to extend the previous findings of autonomous and controlled motivation types towards the TPB in a longitudinal mediation analysis [26]. As internal motives have been found to act as an autonomous perceived locus of control in the formation of attitudes and perceived behavioral control [27], we anticipate that intrinsic motivation and identified regulation will significantly and positively influence attitudes, perceived behavioral control, and intentions over time. In addition, physical activity behavior is suspected to be mediated by intentions, attitudes, and perceived behavioral control. Furthermore, it is expected that external regulation and introjected regulation will exert a significantly negative influence on attitudes and perceived behavioral control, as these regulation types consider controlling motives, in the sense that pressure to comply may hinder one's willingness to perform an action [25]. Finally, external and introjected regulation are hypothesized to exert a significant and positive influence on subjective norms, as subjective norms are generally constructed as representative entities of social pressures to engage in behavior [3].

Taken together, we assume, that, firstly, (Assumption 1) the students' perceptions of all three psychological basic needs will positively influence autonomous motivation (i.e., identified regulation and intrinsic motivation) in PE over time. Secondly, (Assumption 2) we assume that autonomous, controlled motivation (i.e., external and introjected regulation) and amotivation in PE will both positively influence their respective counterparts in LT, and vice versa. Furthermore, autonomous motivation in PE is assumed to influence controlled motivation in LT negatively, and vice versa, while controlled motivation in PE is assumed to influence autonomous motivation in LT negatively, and vice versa. Finally, (Assumption 3) we assume that autonomous motivation will influence the intention and physical activity behavior over time, which we believe to be mediated by attitudes and perceived behavioral control, while controlled motivation should affect subjective norms over time.

2. Methods

2.1. Participants

In total, $N = 1877$ students aged 10 to 23 years ($M = 14.74$ years old; 922 females (49.1%)) were tested at the first wave of the data collection (T1). Subsequently, $N = 194$ (10.4%) students dropped out at T2 (e.g., due to illness) and were not retained in the analyses. As attrition rates from 30 to 70% are often reported in longitudinal studies [28], a dropout rate of around ten percent can be considered negligible. Nevertheless, the N = 194 students reported significantly ($p < 0.05$) lower rates of intrinsic motivation and identified regulation in PE and LT, subjective norms, autonomy, relatedness, and competence support of the PE teacher, while they rated their external regulation (PE) and amotivation (PE and LT) significantly higher. No remaining scales differed (all p-values > 0.05). Of the remaining N = 1681 students (853 females (50.7%); age of M = 14.68 (SD = 2.66) years) included in this study, N = 1140 (67.8%) students were born in Luxembourg, N = 224 (13.3%) in Portugal, and N = 317 (18.9%) in other countries. Additionally, N = 366 students (21.8%) went to elementary schools, while N = 1315 (78.2%) students (376 (22.4%) from the 7th, 459 (27.3%) from the 9th, and 480 (28.6%) from the 11th grade) went to secondary schools. The nine elementary and five secondary schools were selected with the purpose of including each geographical region of the country of Luxembourg. Overall, N = 1060 (63.1%) students chose to fill out the questionnaire in German, N = 555 (33.0%) in French, and N = 66 students (3.9%) switched between the languages during the survey.

2.2. Measures

All questionnaires used in this study were translated from English into German and French using the back-translation technique [29]. Two psychologists from the field of sport psychology separately translated all the scales from English to German and French, while two different psychologists translated the scales back to English. Lastly, the scales were adapted and revised in wording and syntax by a French and German teacher.

Need support. In order to assess the participants' perceived autonomy, competence, and relatedness support of the PE teacher, 16 items out of the 24 items were used, as described in the study of Standage, Duda, and Ntoumanis [30]. All items were preceded by the stem "In this PE class ... " and responses were provided on a 7-point scale (1 = not agree at all, and 7 = totally agree). In order to achieve equivalence in the number of items assessing each subscale, seven out of 15 items were used for autonomy support (α = 0.82). These items were chosen independently and agreed upon by two experienced sport psychologists familiar with the SDT and based on their content-related proximity to the well-established questionnaire Perceived Autonomy Support Scale for Exercise Settings (PASSES) [31]. The following items were included: "we feel that the PE teacher provides us with choices and options"; "the PE teacher shows confidence in our abilities to do well in PE"; "the PE teacher makes sure we really understand the goals of the lesson and what we need to do"; "the PE teacher encourages us to ask questions"; "the PE teacher answers our questions fully and carefully"; "the PE teacher tries to understand how we see things before suggesting new ways to do things"; "we feel able to share our feelings with the PE teacher". Four items were used for competence support (α = 0.83; example item "the PE teacher makes us feel like we are able to do the activities in class") and five items for relatedness support (α = 0.81; example item "we feel that the PE teacher encourages us to work together in class activities"). Confirmatory factor analyses revealed a good model fit for the three factors, χ^2 = 1141.94; df = 101; $p < 0.001$; RMSEA (root mean squared error of approximation) = 0.078; 90% CI (confidence interval) = [0.074; 0.082]; SRMR (standardized root mean square residual) = 0.04; CFI (comparative fit index) = 0.92; TLI (Tucker–Lewis index) = 0.91. Factor loadings ranged from 0.45 to 0.73 for autonomy support, from 0.63 to 0.74 for relatedness support, and from 0.71 to 0.77 for competence support.

Motivation in PE. The revised Perceived Locus of Causality Scale (PLOC-R) [32] was used to measure the behavioral regulation in PE. Following the stem "I participate in PE ... ", the students provided their answers on 20 items with a 7-point scale (1 = not agree at all, and 7 = totally agree). Each of the subscales consisted of four items for amotivation (α = 0.80; example item "But I don't see why I should have PE"), external regulation (α = 0.71; example item "Because I'll get into trouble if I don't"), introjected regulation (α = 0.68; example item "Because I would feel bad about myself if I didn't"), identified regulation (α = 0.85; example item "Because it is important to me to try in PE"), and intrinsic motivation (α = 0.82; example item "Because PE is fun"). Factor loadings ranged from

0.68 to 0.74 for amotivation, from 0.48 to 0.73 for external regulation, from 0.58 to 0.69 for introjected regulation, from 0.74 to 0.80 for identified regulation, and from 0.66 to 0.80 for intrinsic motivation. For further psychometric details, please refer to Hutmacher, Eckelt, Bund, and Steffgen [33].

Motivation in LT. The 19-item Behavioral Regulation in Exercise Questionnaire (BREQ-II) [34] was used to assess the behavioral regulation in LT. Students provided their answers on a 7-point scale (1 = not agree at all, and 7 = totally agree). The subscales amotivation (α = 0.86; example item "I think exercising is a waste of time"), external regulation (α = 0.80; example item "I exercise because other people important to me say I should"), identified regulation (α = 0.76; example item "I value the benefits of exercise"), and intrinsic motivation (α = 0.87; example item "I exercise because it's fun") each consisted of four items, while the subscale introjected regulation (α = 0.69; example item "I feel guilty when I don't exercise") contained three items. Factor loadings ranged from 0.73 to 0.84 for amotivation, from 0.66 to 0.77 for external regulation, from 0.59 to 0.72 for introjected regulation, from 0.47 to 0.79 for identified regulation, and from 0.72 to 0.85 for intrinsic motivation (please refer to Hutmacher, Eckelt, Bund, and Steffgen [33] for further psychometric details).

Constructs of the theory of planned behavior (TPB). Items from Hagger and colleagues [3], which were adapted according to the procedure proposed by Ajzen and Madden [35], were used. The *attitude* to engage in physical activity (α = 0.90) was recorded using seven bipolar adjectives (e.g., unpleasant–pleasant) with the introductory stem "I find being physically active in my free time at least 60 minutes a day ...". Factor loadings ranged from 0.66 to 0.80. All adjectives were rated on a 7-point semantic differential scale, with higher values representing the positive adjective. *The perceived behavioral control* to become physically active regularly in the free time was recorded using three items (α = 0.77). Factor loadings ranged from 0.70 to 0.75. Two items (example item "I have full control over whether I am active in my free time for at least 60 minutes a day") were rated on a 7-point scale (1 = not agree at all, and 7 = totally agree), and the item "How much control do you have about being physically active in your free time for at least 60 minutes a day" was rated on a 7-point scale from 1 ("no control at all") to 7 ("complete control"). To assess the *subjective norm*, three items based on the injunctive norm (e.g., "People who are important to me encourage me to be physically active in my free time") were used. These items showed an internal consistency of α = 0.65 and were rated on a 7-point scale (1 = not agree at all, and 7 = totally agree). The *intention* to become physically active was measured using two items (α = 0.79). The item "I intend to be physically active for at least 60 minutes a day for the next 5 weeks" was rated on a 7-point Likert scale (1 = not agree at all, and 7 = totally agree), and the second item "I intend to be physically active at least 60 minutes a day with the following regularity" was recorded on an 8-point Likert scale (0 = never, 7 = daily). The *subjectively perceived physical activity* behavior during LT was assessed via two items, "On how many days of a regular week are you physically active for at least 60 minutes?" and "On how many days were you physically active for at least 60 minutes over the last seven days?", on an 8-point scale (0 = never, to 7 = on each day).

2.3. Procedure

Each of the two data collection waves lasted for around two months and was performed digitally via self-report questionnaires using the secured platform OASYS [36] (University of Luxembourg, Esch-sur-Alzette, Luxembourg). Due to the advantage of digital testing, no missing data need to be reported. The questionnaires were filled out at school during class on a computer or tablet under the continuous supervision of trained research assistants. The first data collection (T1) took place during the first trimester of the participants' school year in autumn. The second data collection (T2), consisting of the same questionnaires, was performed six months later during the third trimester of the participants' school year in spring. Assessing the students twice during one school year leads to a reduced percentage of dropouts, while, simultaneously, six months can be considered as a sufficient period to capture potential substantial change in adolescents' values and behaviors (e.g., physical maturation) [37]. Ethical approval was provided by the Ethics Review Panel of the University of Luxembourg. Signed informed consent forms were required from all participants in order to take part in our study, while written permission was additionally needed from the legal representatives of all participants younger than 16 years.

2.4. Statistical Analysis

As a longitudinal design was chosen, measurement invariance (MI) has to be controlled for, since the different scales should measure the same construct over time [38]. Given the sensitivity of the χ^2 statistics to sample size, model fit assessment was primarily based on the remaining fit indices. According to the cut-off value criterion of Cheung and Rensvold [39] suggesting a ΔCFI (change in the Comparative Fit Index) of -0.01, we found evidence that all reported scales showed strict measurement invariance (equal pattern loadings, loading values, intercepts of each item, and residual variances) over the two measurement points. Furthermore, the univariate and multivariate distributions of the items and the scales' internal reliability and factorial structure were tested and revealed good psychometric properties. As MI over time is given, the psychometric properties are reported only for T1. A minimum value of 0.40 was accepted for factor loadings [40].

In order to analyze Assumption 1, a generalized linear mixed model (GLMM) [18] was conducted to model within-subject correlations over time, while simultaneously controlling for age and sex. The specified model can be defined as $Y_{ij} = \beta_o + b_{0a} + b_{0r} + b_{0c} + \beta_{1T} + \beta_{2A} + \beta_{3S}$, while Y_{ij} denotes the logit of intrinsic motivation or identified regulation, β_{1T}, β_{2A} and β_{3S} reflect the three respective fixed terms time, age, and sex, and β_o represents the *general intercept*. The three predictors, with varying intercepts on Y_{ij} being controlled for by the GLMM approach, are listed as b_{0a} for autonomy support, b_{0r} for relatedness support, and as b_{0c} for competence support. Secondly, to analyze the interactions and reciprocal influences between the variables over a two-time period, a Cross-Lagged Panel Model (CLPM) was used, as described by Mund and Nestler [22], for Assumption 2. Thirdly, a longitudinal mediation model, as described in Jose [26], was conducted addressing Assumption 3. Responses to items measuring the same construct were averaged for use in the correlation and path analyses. Exogenous variables were allowed to correlate, as well as the disturbances of the endogenous variables. Model fit of the CLPM, the confirmatory factor analysis (CFAs), and the longitudinal mediation model was evaluated with the root mean squared error of approximation (RMSEA), accompanied by a 90% confidence interval (CI), the standardized root mean square residual (SRMR), comparative fit index (CFI), and Tucker–Lewis index (TLI). Based on the cut-off values from Hu and Bentler [41], a reasonable fit was accepted (RMSEA < 0.08; SRMR < 0.12; CFI > 0.90; TLI > 0.90).

In order to perform the statistical analyses, the 25th version of the "Statistical Package for the Social Sciences" (SPSS) [42] (IBM Corp, Armonk, NY, USA) software was used for data transformation, descriptive analyses, and independent sample t-tests. Version 3.6.1 of R [43] (R Foundation for Statistical Computing, Vienna, Austria) and the package lme4 [44] were used for the GLMM analysis (Assumption 1), and the package lavaan [45] was used for the CFAs. In addition, Amos 26 [46] (IBM SPSS, Chicago, IL, USA) was used to perform the CLPM and longitudinal mediation model (Assumptions 2 and 3). Finally, measurement invariance analyses were performed with Mplus 5.0 [47] (Muthén & Muthén, Los Angeles, CA, USA).

3. Results

3.1. Preliminary Analysis

As the measures for motivational regulation in PE and LT share equal constructs, one might have doubts with regard to the construct validity of these two very similar scales. In order to address this question, two CFAs were conducted and tested against each other. The first congeneric model consisted of five factors, on which all indicators of the perceived locus of causality in PE and LT were loaded. For example, the items of intrinsic motivation from PE and LT were loaded on one overarching factor. This congeneric model with five factors revealed an unsatisfactory model fit, χ^2 = 6931.12.; df = 655; p < 0.001; RMSEA = 0.075; 90% CI = [0.074; 0.077]; SRMR = 0.098; CFI = 0.741; TLI = 0.722, with factor loadings ranging between 0.31 and 0.79. In a second model, the indicators of the perceived locus of causality in PE and LT were loaded on ten distinct factors and revealed a satisfactory model fit, χ^2 = 2281.90.; *df* = 620; $p < 0.001$; RMSEA = 0.040; 90% CI = [0.038; 0.041]; SRMR = 0.054; CFI = 0.931; TLI = 0.922, with factor loadings ranging between 0.46 and 0.85. When comparing these models, the model with ten factors fitted significantly better ($\Delta\chi^2$ = 3351.5, $p < 0.001$).

The correlation coefficients and descriptive statistics among all psychological measures are presented in Table 1. Similar scales correlated higher beyond the two different questionnaires, which confirms convergent validity. For instance, intrinsic motivation in PE (PLOC-R) correlated with intrinsic motivation in LT (BREQ-II). In addition, simplex pattern correlations between the five factors of the continuum for motivational regulation in PE and LT were found and, thus, support the theoretically expected relationship pattern between the subscales [32,34]. For example, a greater correlation was revealed between intrinsic motivation during PE and identified regulation in PE (r = 0.73) than with introjected regulation in PE (r = 0.12). All correlations according to the TPB were obtained in the expected way [23]. As such, attitudes, subjective norms, and perceived behavioral control towards physical activity were positively related to the intention of getting physically active, which, in turn, was related to actual physical activity.

Participants subjectively reported on average M = 3.21 (SD = 1.97) days of at least 60 minutes of physical activity at T1 and M = 3.32 (SD = 1.99) at T2. Overall, 8.3% of the adolescents at T1 and 9.5% at T2 reported being physically active for at least 60 minutes every day.

3.2. Assumption 1: The Students' Perceived Basic Needs Support by the Teacher Influences the Students' Motivation in PE

In order to test if the support of the three basic psychological needs had an impact on intrinsic motivation and identified regulation, two GLMM models were conducted controlling for time, age, and sex. Overall, results of the GLMM analyses, which are presented in Table 2, showed that the students' perceived autonomy support, relatedness support, and competence support of the PE teacher significantly predicted intrinsic motivation and identified regulation. Competence support was the strongest predictor for both intrinsic motivation (β = 0.27; $p < 0.001$) and for identified regulation (β = 0.35; $p < 0.001$). The three predictors explained 26% of the variance in intrinsic motivation and 27% of variance in identified regulation, while the full GLMM was able to explain 67% of the variance in intrinsic motivation and 61% in identified regulation when also taking time, age, and sex into account.

3.3. Assumption 2: School-Related PE Motivation Persists in an Out-of-School (LT) Context

In order to analyze the transfer of motivation from the context of PE towards the context of LT, as well as from LT to PE, the impact of the students' perceived intrinsic motivation, identified regulation, introjected regulation, external regulation, and amotivation towards PE was tested against the same factors towards LT, and vice versa, in a cross-lagged analysis. The respective significant paths are shown in Figure 1.

Except for external regulation in PE, external regulation in LT, and identified regulation in LT, all directly related motivational types influenced each other over time and context. The model showed a good fit to the data, χ^2 = 450.71; *df* = 40; $p < 0.001$; RMSEA = 0.078; 90% CI = [0.072; 0.085]; SRMR = 0.05; CFI = 0.98; TLI = 0.90. Overall, the model explained a considerable proportion of variance in all six outcomes at T2, for intrinsic motivation in PE (R^2 = 0.30), identified regulation in PE (R^2 = 0.27), introjected regulation in PE (R^2 = 0.21), external regulation in PE (R^2 = 0.22), amotivation in PE (R^2 = 0.24), intrinsic motivation in LT (R^2 = 0.32), identified regulation in LT (R^2 = 0.29), introjected regulation in LT (R^2 = 0.23), external regulation in LT (R^2 = 0.22), and amotivation in LT (R^2 = 0.21).

Table 1. Means, standard deviations, and intercorrelations of the study variables.

	M	SD	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
1. Amotivation (PE)	2.31	1.35	-																	
2. External Regulation (PE)	3.50	1.53	0.50 *	-																
3. Introjected Regulation (PE)	3.21	1.58	0.27 *	0.50 *	-															
4. Identified Regulation (PE)	5.13	1.41	−0.35 *	−0.04	0.24 *	-														
5. Intrinsic Motivation (PE)	5.20	1.37	−0.45 *	−0.18 *	0.12 *	0.73 *	-													
6. Amotivation (LT)	2.12	1.40	0.51 *	0.33 *	0.24 *	−0.12 *	−0.20 *	-												
7. External Regulation (LT)	2.83	1.52	0.23 *	0.30 *	0.39 *	0.16 *	0.08 *	0.46 *	-											
8. Introjected Regulation (LT)	3.64	1.62	0.01	0.16 *	0.36 *	0.31 *	0.23 *	0.12 *	0.42 *	-										
9. Identified Regulation (LT)	5.06	1.29	−0.30 *	−0.11 *	0.10 *	0.50 *	0.49 *	−0.27 *	0.12 *	0.46 *	-									
10. Intrinsic Motivation (LT)	5.37	1.40	−0.37 *	−0.19 *	0.02	0.50 *	0.58 *	−0.34 *	0.03	0.31 *	0.80 *	-								
11. Autonomy support (PE)	5.00	1.10	−0.25 *	−0.03	0.07 *	0.50 *	0.48 *	−0.06 *	0.13 *	0.19 *	0.36 *	0.38 *	-							
12. Relatedness support (PE)	5.37	1.12	−0.26 *	−0.06 *	0.04	0.45 *	0.48 *	−0.13 *	0.04	0.12 *	0.34 *	0.38 *	0.82 *	-						
13. Competence support (PE)	5.38	1.20	−0.29 *	−0.06 *	0.04	0.50 *	0.50 *	−0.12 *	0.06 *	0.16 *	0.37 *	0.39 *	0.82 *	0.81 *	-					
14. Attitudes	5.64	1.21	−0.31 *	−0.21 *	−0.06 *	0.33 *	0.38 *	−0.28 *	−0.06 *	0.12 *	0.45 *	0.52 *	0.25 *	0.24 *	0.26 *	-				
15. Subjective norms	4.72	1.57	0.02	0.10 *	0.20 *	0.25 *	0.19 *	0.17 *	0.43 *	0.31 *	0.26 *	0.20 *	0.25 *	0.20 *	0.20 *	0.19 *	-			
16. Perceived control	5.23	1.36	−0.17 *	−0.09 *	−0.01	0.31 *	0.31 *	−0.13 *	−0.002	0.18 *	0.43 *	0.47 *	0.32 *	0.30 *	0.30 *	0.39 *	0.22 *	-		
17. Intentions	4.27	1.64	−0.21 *	−0.14 *	0.03	0.37 *	0.35 *	−0.18 *	0.08 *	0.26 *	0.58 *	0.56 *	0.28 *	0.26 *	0.28 *	0.48 *	0.23 *	0.54 *	-	
18. Physical activity (LT)	3.17	1.90	−0.17 *	−0.14 *	−0.02	0.21 *	0.24 *	−0.17 *	−0.02	0.13 *	0.42 *	0.43 *	0.18 *	0.18 *	0.20 *	0.33 *	0.10 *	0.40 *	0.62 *	-

Notes. * $p < 0.05$; PE = physical education context; LT = leisure-time context.

Table 2. Results of the generalized linear mixed model (GLMM) investigating the effects of autonomy support, relatedness support, and competence support in PE for intrinsic motivation and identified regulation when controlling for time, age, and sex.

	Intrinsic Motivation					Identified Regulation				
Fixed Effects	**Estimate**	**SE**	β	t	p	**Estimate**	**SE**	β	t	p
Intercept	1.76	0.22	0.00	7.94	<0.001	1.56	0.16	0.00	9.69	<0.001
Autonomy support	0.16	0.03	0.13	6.24	<0.001	0.19	0.03	0.14	6.91	<0.001
Relatedness support	0.19	0.03	0.16	6.63	<0.001	0.08	0.03	0.07	2.61	<0.01
Competence support	0.30	0.03	0.27	11.19	<0.001	0.40	0.03	0.35	13.70	<0.001
Random Effects	**Variance**	*SD*				**Variance**	*SD*			
Time	0.65	0.81				0.63	0.79			
Age	0.05	0.23				0.06	0.24			
Sex	0.06	0.25				0.01	0.11			
Observations	3362					3362				
Marginal R^2	0.26					0.27				
Conditional R^2	0.67					0.61				

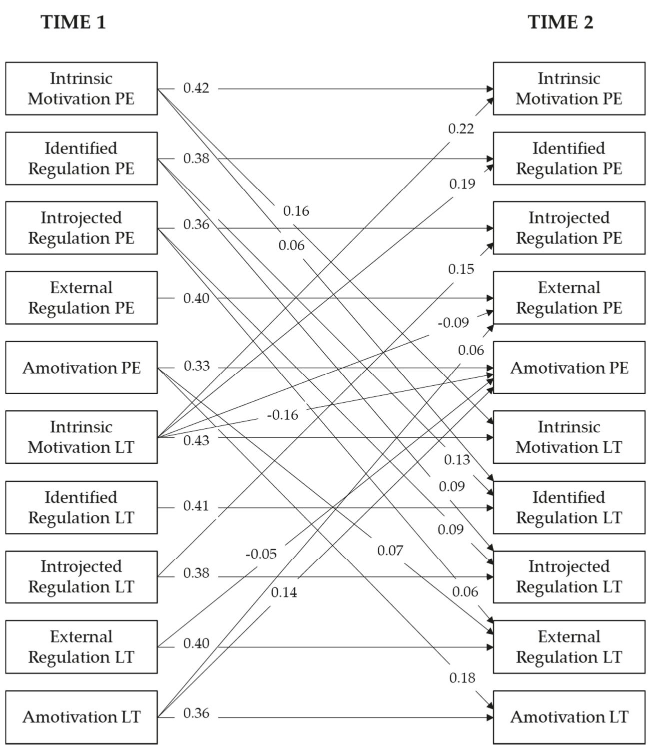

Figure 1. Standardized paths of a cross-lagged panel model of the five different factors of motivation in physical education (PE) and in leisure-time (LT). All cross-lagged paths between the five motivational types in PE and LT were calculated. Only significant paths are presented ($p < 0.05$).

3.4. Assumption 3: Motivation in LT Influences Physical Activity Behavior in LT

In order to analyze the impact of autonomous motivation, controlled motivation, and amotivation on intentions and physical activity in LT, and the potential mediations of attitude, subjective norm, and perceived behavioral control, a longitudinal mediation analysis was conducted. The respective modeled paths are presented in Figure 2. Statistical significance was obtained for all paths in line with the proposed assumptions. As a direct significant path from intrinsic motivation towards physical activity behavior was present, the two serial mediation paths from intrinsic motivation on attitudes (perceived behavioral control) on intention and finally on behavior were calculated and revealed significance ($\beta_{attitude} = 0.02$; $p < 0.01$; $\beta_{control} = 0.01$; $p < 0.05$). Additionally, as identified regulation directly predicted the intention of becoming physically active, two further mediation paths from identified regulation on attitudes (perceived behavioral control) and on intention were conducted and showed significance ($\beta_{attitude} = 0.01$; $p < 0.001$; $\beta_{control} = 0.01$; $p < 0.05$). The further five full mediation analyses of identified regulation, external regulation, and amotivation on physical activity behavior were conducted and found to be significant ($p < 0.05$). The model showed a good fit to the data, $\chi^2 = 323.60$; $df = 30$; $p < 0.001$; RMSEA = 0.076; 90% CI = [0.069; 0.084]; SRMR = 0.06; CFI = 0.97; TLI = 0.91. Overall, the model explained a considerable proportion of variance in all nine outcomes, for attitude at T1 ($R^2 = 0.28$), perceived behavioral control at T1 ($R^2 = 0.23$), subjective norm at T1 ($R^2 = 0.24$), attitude at T2 ($R^2 = 0.12$), perceived behavioral control at T2 ($R^2 = 0.18$), subjective norm at T2 ($R^2 = 0.14$), intention at T1 ($R^2 = 0.37$), intention at T2 ($R^2 = 0.40$), and physical activity at T2 ($R^2 = 0.40$).

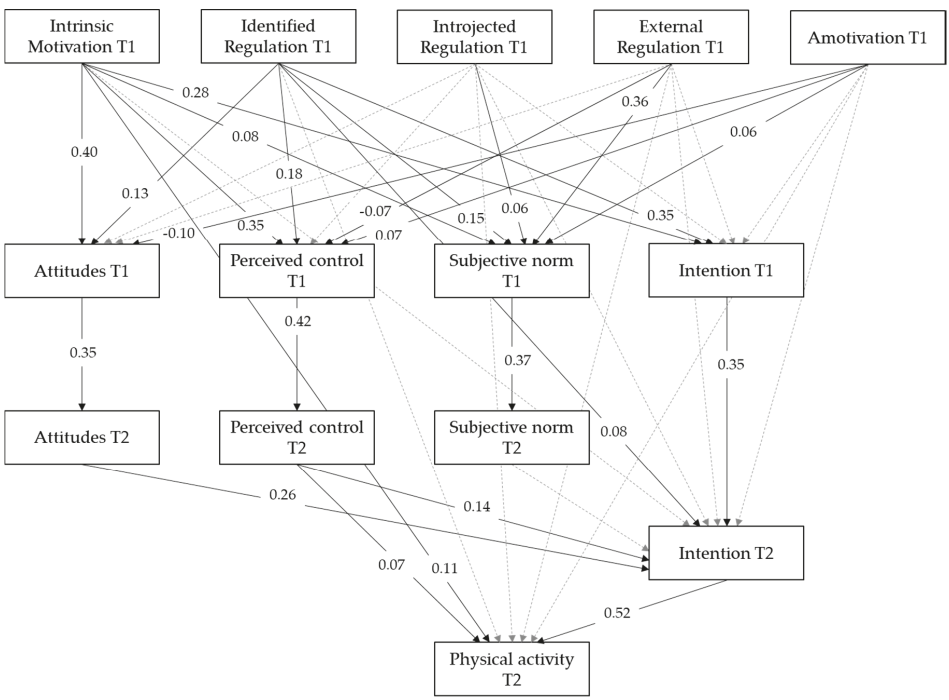

Figure 2. Longitudinal mediation model of the five different factors of motivation in leisure-time (LT) on intention and physical activity mediated by attitude, perceived behavioral control, and subjective norm. All calculated paths are presented: solid arrows represent significant paths ($p < 0.05$), while dashed arrows represent non-significant paths ($p > 0.05$).

4. Discussion

The overarching aim of this study was to investigate if motivational regulation during PE is related to the motivational regulation of physical activity during the students' LT, and if their perceived need-support from the teacher enhances this transfer between the school and out-of-school context. Therefore, the assumptions of the trans-contextual model [6] were analyzed in a longitudinal design.

Based on the first assumption (1), we found that the students' perceived autonomy, competence, and relatedness support from the PE teacher were, as expected, related to intrinsic motivation and identified regulation in PE over time. Thus, while controlling for time, age, and sex, all students perceived higher autonomous motivational rates when they perceived their PE teacher as need-supportive. Interestingly, in accordance with our theoretical expectations and in addition to previous research [16], we found that over and above the support of autonomy support during PE, competence support and relatedness support functioned as significant factors to impact autonomous motivation in PE. In line with the findings of Kiemer, Gröschner, Kunter, and Seidel [48], we found that, over time, competence support functioned as an important prerequisite for students' self-determination in school. The authors further suggest that it is important to consider how the teacher supports competence, as communication in a context of respect, with a meaningful rationale, is crucial. In this sense, it is not surprising that, next to competence, our results revealed that also the support of relatedness, thus, a good social climate in class, significantly improved autonomous motivation. In sum, we therefore suggest that PE teachers support autonomy (i.e., providing choice of activities), competence (i.e., setting realistic goals and promoting a feeling of ability to succeed), and relatedness (i.e., spreading a feeling of respect and kindness) simultaneously, in order to significantly strengthen the self-induced (i.e., internal) motivational regulation of their students. Furthermore, we suggest implementing competence and relatedness support in the trans-contextual model, as we believe it will provide incremental value to the model, as 67% of intrinsic motivation and 61% of identified regulation were explained.

According to the second assumption (2), the postulated transfer of motivational regulation between contexts could be confirmed. Indeed, as proposed in the trans-contextual model, we found that autonomous motivation (i.e., intrinsic motivation and identified regulation) in a school context (PE) was directly related to autonomous motivation in LT [6] and vice versa. These results confirm that motivational regulation is transferable to similar activities in a different context [20]. Furthermore, these findings point out the importance of education, as teachers' encouragement of their students' autonomous motivation during PE is likely to persist in LT. Furthermore, intrinsic motivation in LT over time was related to intrinsic motivation in PE, meaning that students, who like to be physically active during LT because they like the activity itself, are also likely to implement this intrinsic motivation during PE. In addition, intrinsic motivation in LT was negatively related to external regulation and amotivation in PE, showing that students who appreciate physical activity in their free time do no not value external motivators in PE. Opposed to the transfer from PE to LT, identified regulation was not related from LT to PE over time. A possible explanation for the absence of this transfer might be that students identify with different values in LT compared to PE. Successful internalization, termed identification, involves the integration of formerly external regulations into one's sense of self, typically in the form of important personal values, which are dynamic and dependent upon social-contextual support [49]. Likewise, it might be the case that, in LT, identified regulatory motives rather represent the benefits of physical activity in a more global setting, while in PE, the students were primarily asked whether it is valuable for them to try and accomplish new activities. These results suggest that the identified values seem to be transferable only from a more specific school-related context to more global physical activity values in LT, but, at the same time, these values from an out-of-school context were not implemented in PE.

Additionally, we found that introjected regulation and amotivation in PE were related to introjected regulation and amotivation in LT over time, which was also the case for the transfer from LT towards PE. A cross-contextual transfer of introjected regulation may imply that if students become physically active based on internalized external contingencies, they are very likely to transfer these regulatory motives between the PE and LT context. Furthermore, if students are not motivated towards physical activities at all, they tend to remain amotivated in both contexts. Interestingly, external regulation was not transferred over time and context. An explanation for this absence might be that external regulatory motives differ between the school and out-of-school context, as, for instance, external drivers in school are rules or grades, while, in LT, external drivers are significant others, who want one to be physically active. However, these external motives in LT negatively influenced amotivation in PE over time, meaning that the pressure of significant others to become physically active reduced the feeling of not knowing why physical activity is of importance (i.e., not a waste of time) in school.

Finally, addressing the third assumption (3), we found evidence for the claims made by the trans-contextual model, namely that intrinsic motivation and identified regulation predict physically active behavior in a way that is significantly mediated by intention, attitude, and perceived behavioral control. However, we also found a direct effect of intrinsic motivation on physical activity over time, which represents a partial mediation. Identified regulation directly affected the intention of becoming physically active, while the mediation through attitude and perceived behavioral control was also significant, thus representing another partial mediation. These findings are consistent with the findings of Teixeira, Carraça, Markland, Silva, and Ryan [50], who in their systematic review found that identified regulation predicted initial and short-term behavior, while intrinsic motivation rather predicted long-term exercise adherence. On the one hand, identified regulation relies on rather external but personally important values implemented to the self, which may explain a direct effect on intention rather than a long-term effect on physical activity. On the other hand, intrinsic motivation implies that being physically active is inherent by nature and, thus, in the long-term, directly related to the behavior itself. However, it should be noted that, while inherently perceiving the activity as being fun and interesting is important to sustain a long-term regular engagement in exercise, it requires engagement and effort to continue performing repetitive activities, which requires identification with the outcomes [51]. Furthermore, as expected, introjected regulation, external regulation, and amotivation were related to subjective norm, as externally controlled motivators are present in these constructs. Contrary to the theory of planned behavior, but in accordance with the findings of Hagger and colleagues [3], subjective norm was not significantly related to intention in our model. We assume that the internal motivators in autonomous motivation, attitudes, and perceived behavioral control explain substantially more variance in intention than the external drivers in introjected regulation and external regulation mediated by subjective norm, as also suggested by previous research [52]. In contrast to our assumption, beyond the expected significant path of controlled motivation types on subjective norm, intrinsic motivation and identified regulation were significant predictors. In fact, there is a disagreement in the scientific literature, as some scholars claim that the concept of subjective norms concerning social pressures is less likely to be aligned with autonomous motivation [52]. However, evidence for the above-mentioned path can be found in a recent meta-analysis [6]. The positive relation between autonomous motivation and subjective norm may be explained by the individuals' recognition and respect of the desires of significant others and may be viewed as supportive and in accordance with self-endorsed values. Future studies should aim at investigating the particular relationship between autonomous motivation and subjective norm in more depth. As expected, amotivation negatively predicted attitude and positively predicted subjective norm; however, perceived behavioral control was also positively predicted. Even though amotivation represents the lack of any personal causal value of becoming physically active, this does not necessarily indicate that the students perceive to have no control over their behavioral actions. Thus, the students might perceive to have behavioral control over their actions but simply do not see any value in being active. In accordance with previous findings [53], we suggest that amotivation should be conceptualized in studies as a multidimensional construct, because different reasons may result in a lack of motivation (i.e., ability beliefs, effort beliefs, characteristics of the task, and value placed on the task).

On a more general level, we have seen that the different types of autonomous motivation are transferable from PE to LT, and vice versa. Consequently, this finding raises two questions. Firstly, how can PE teachers ideally motivate their students in a way that their autonomous motivation also persists in LT? Our results and previous findings suggest that the support of the psychological basic needs does increase autonomous motivation, as the fulfillment of basic needs is essential for ongoing psychological growth, integrity, and wellbeing [13]. Intervention programs—for instance, autonomy-supportive intervention programs for teachers [14]—have been successful in reducing controlling strategies in teaching. More specifically, five instructional behaviors have been found to be key elements: vitalizing rather than neglecting students' inner motivational resources (e.g., using instructional strategies to spark interest in an intrinsic goal), relying on informational rather than on controlling language (e.g., saying "you may" rather than "you have to"), providing instead of neglecting explanatory rationales, displaying patience rather than pressuring students, and acknowledging and accepting students' complaints and expressions of negative affect. Furthermore, supporting their students' autonomy allows the teacher to provide choice in order to impart freedom to determine their own behavior [54]. A sense of ownership and volition further enhances the feeling of being in control of one's own actions [55]. Competence support refers to the ongoing provision of feelings of success in the students by the teacher, with, for example, guidance, optimal challenges for the individual student, and appropriate feedback. When teachers utilized these autonomy and competence supportive strategies, increased experiences of self-determination and intrinsic learning motivation of their students were found [48]. Moreover, the practical implications of relatedness support in class should be noted, as supportive relationships with teachers have been found to be key factors for students' emotional engagement and academic achievement [56,57]. According to the students' perception, the teacher's communication (e.g., individualized and friendly), their in-class social support (e.g., promoting cooperation and teamwork), and behaviors associated with the teacher's attentiveness (e.g., awareness and caring behaviors) were rated as highly relatedness-supportive in class [58]. Secondly, as motivational regulation in LT was related to the motivational regulation in PE, an additional path to foster an overall internal regulation might be the promotion of autonomous motivation and the support of basic needs at home. One potential consideration represents a home–school partnership, as, for instance, parents' involvement, autonomy support, and structure contribute to higher autonomous motivation and engagement of their children [59]. Furthermore, another great opportunity for students is to participate in school-based after-school programs, which were linked to numerous positive development outcomes including higher values of perceived guidance, facilitated relations to peers, and the opportunity to pursue particular skills and competencies in an autonomous climate [60].

Ultimately, the trans-contextual model has proven to be a key concept to transfer students' motivation in physical activity from the classroom to an out-of-school-context. Recent research has expanded this model by obtaining further evidence for the contextual transfer of motivation beyond the context of physical activity in school, as, for instance, autonomous motivation towards mathematics in school was found to be related to autonomous motivation towards math homework [61]. Furthermore, by means of our study, we have provided evidence for the perpetually present mechanisms of the trans-contextual model for the first time, by illustrating the links between motivational constructs of students to be persistent over time.

Limitations and Suggestions for Future Research

One limitation of the present study is the analyses being restricted to two measurement points. Future research should further examine the theoretical assumptions on more occasions in order to provide additional support for the causal interactions of the proposed paths of the trans-contextual model. The CLPM contains a number of assumptions, which may make its results more difficult to interpret [22]. To represent the dynamic nature of life course theories, for example, three to four measurement occasions would provide insights into the model-implied developmental trajectory and would allow us to take into account the within-person stability properly. A further limitation of this study is the sole use of self-report measurements. Future research could implement objective measurements, as, for example, behavioral differences between subjectively and objectively measured physical activity have been found [62]. The same applies to the support of the basic psychological needs by the PE teacher, which may be analyzed through observations or teacher reports. Moreover, the questionnaire that we used to assess the students' basic need support has not yet been empirically validated. Given the lack of available questionnaires capturing all three constructs of basic need support simultaneously, we adapted the questionnaire described in Standage and colleagues [30] and found good psychometric properties for our representative sample. However, in general, we would like to stress the need for upcoming studies to empirically validate a basic need support questionnaire incorporating autonomy support, competence support, and relatedness support. Furthermore, the two questionnaires (PLOC-R and BREQ-II) used in this study fell short of capturing "integrated regulation". Since we aimed at assessing the students' motivation in PE, the PLOC-R was the only available questionnaire at the time of our data collection. In order to differentiate accurately between motivation in the PE and LT context, we chose the BREQ-II for the LT context due to its similar overarching structure to the PLOC-R. Nevertheless, with regard to future studies, we would like to recommend the inclusion of "integrated regulation" in order to measure the full continuum of motivational regulation in the SDT. In addition, some differences with regard to motivation and basic psychological needs were found for the participants who dropped out. Thus, the dropout sample is representative of a specific population. However, our attrition rate was primarily due to students being absent on the second measurement occasion, for which motivational aspects were found to be a key factor in previous research [63]. A further limitation of the present study is that the conceptual questions were restrictively oriented toward the context of physical activity. However, the trans-contextual transfer of autonomous motivation might be present beyond the context of PE, which should be investigated accordingly in future studies.

5. Conclusions

In order to come back to the initial question about the trans-contextual modality of motivation, the results of the present study strongly support its transferability between PE and LT. We initially mentioned that one of the main goals in education is the transfer of the learned skills and competencies towards the everyday life of the students. Specifically in PE, one goal is to motivate the students to also remain or become physically active in an out-of-school context. The present study revealed that, in the long term, autonomy support, competence support, and relatedness support by the PE teacher positively influence autonomous motivation of students in PE. When considering the alarmingly low percentage of adolescents spending at least one hour of their LT in physical activity, which is related to numerous adverse health consequences [64,65], PE teaching represents an important domain to intervene. Nevertheless, beyond the assumption of the unidirectional impact of PE on LT, motivational regulation towards similar activities is trans-contextually interrelated. Thus, the promotion of motivational regulation styles in out-of-school contexts should not be ignored, as they are directly related to PE. Furthermore, we provided evidence that indeed the self-determination theory could be integrated into the theory of planned behavior; thus, autonomous motivation is related to physical activity behavior and intention, mediated by attitude and perceived behavioral control.

Author Contributions: Conceptualization, D.H., M.E. and G.S.; Data curation, D.H. and M.E.; Formal analysis, D.H.; Funding acquisition, A.B. and G.S.; Investigation, D.H.; Methodology, D.H. and M.E.; Project administration, A.B. and G.S.; Supervision, A.B. and G.S.; Visualization, D.H.; Writing—original draft, D.H.; Writing—review & editing, D.H., M.E., A.B. and G.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the University of Luxembourg [Internal Research Projects], under the grant Physical Activity Behavior of Children and Youth in Luxembourg: The Role of Physical Education [IRP17-PALUX].

Acknowledgments: We thank all the schools, teachers and children who participated in the study. We also thank the SCRIPT (Service de Coordination de la Recherche et de l'Innovation pédagogiques et technologiques) and the APEP (Association des Professeurs d'Éducation Physique a.s.b.l.) for assistance in organizing this project.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Learning Strategies Focused on Decision Making and Collaboration on Physical Education

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Received: 29 September 2020; Accepted: 26 October 2020; Published: 28 October 2020

Abstract: This research analyzes the voices of university students of sport sciences during the implementation of strategies to support autonomy and collaboration in gymnastic learning, from the perspectives of self-determination, self-control, and self-regulation. The methodology is qualitative and the self-reflective journals with their narrative are the tool to collect information. The strategy is well appreciated both in terms of the structure of the work plan and in the guidance of the tasks. The evolution of motivation, autonomy, collaboration, and achievements is highly valued throughout the process. However, the final assessment, despite having little effect on the grade, produces pressure and anxiety in students, so that self-control decreases, action is impaired, and the motivation achieved in the learning process is distorted. Further studies are needed to design coping strategies to help students maintain their motivation and confidence and to decrease students' resistance to assessment tasks.

Keywords: university students; gymnastic skills; autonomy support; self-control

1. Introduction

1.1. Motivations and Resistances toward Physical Education in University Students

Within the framework of theories attempting to change behavior, specifically in the field of physical education (PE), the theory of self-determination has been especially researched [1]. We believe that the term determination is more accurate than motivation because it implies an important decision-making power. It is common for teachers to be able to get students motivated at first, but if they lack a strong driving force, the initial motivation may gradually diminish. There are many authors who develop and research these theories prolifically, Deci and Ryan [2], Ryan and Deci [1,3], as well as Reeve [4,5] in the field of motivation applied to teaching and learning, together with Haerens et al. [6] and Vansteenkiste et al. [7], among others. In general, all the authors mentioned identify three basic needs in students whose attention is a priority for teachers. The need for autonomy, the need for achievement and training, and the need for interrelationships.

The term autonomy, directly related to motivation, refers to the need for self-regulation of learning and has a social and practical meaning concerning the choice and involvement [8]. Secondly, Deci and Ryan [2] and Ryan and Deci [9] report that the need for training, competence, and achievement is a powerful incentive for an ongoing effort and perseverance. Therefore, it is better to get students to regulate themselves internally than to rely on reward and punishment. There are autonomy-oriented personalities who regulate their behavior in terms of possibilities and choices. Those who are control oriented, instead, regulate their conduct by focusing on rewards and punishments. It is thus very important in the teaching of PE to support autonomy and to avoid encouraging external motivation, which always makes individuals more dependent on the context [10]. As a third element, they establish the need for relationships, a powerful engine that pushes us to interact with others and feel connected to others. Curran et al. [11] analyzed the theory of SDT self-determination and found that when, for example, coaches used support for autonomy and interpersonal control in teams, greater involvement was more likely to follow. The need for enjoyment, closely linked to socialization, was also highlighted by several research studies, as a motivation to invest effort in a task. Woods et al. [12] found enjoyment to be the most influential motive affecting participation in physical activity and PE.

In short, the self-determination approach emphasizes that these needs help to establish commitment to tasks and must be considered and used in the learning of PE. We agree that these initial needs and motivations must be turned into stable capacities and they need, therefore, adequate learning strategies. For instance, autonomy is a must, but if it is not worked on and exercised, it loses effectiveness, and since its real implementation in different contexts and situations can lead to difficulties, some students may opt for dependency. Likewise, one can also take into consideration whether there are other related needs such as self-esteem or pleasure and the relationship between ability, motivation, and opportunity [13] as they are also determining factors.

Numerous studies, with greater or lesser connection to the self-determination theory framework, concur that positive attitudes were strongly associated with obtaining physical, personal, and social benefits from PE [14,15], which clearly corresponded to the students' needs. Nevertheless, considering that benefits demand effort, a motivation must be defined by the conscious assessment of physical activity, which implies a cognitive and mental action [16] if we want to give rise to a continuous practice of physical and sport activity in the future.

1.2. Context of the Research: The Implementation of the Strategy to Support Autonomy and Collaboration in the Gymnastic Field

PE teachers find it difficult to move from the old pedagogies to the new ones, even though the latter allow them to anticipate students' responses, know their needs, and encourage them in taking responsibility and making independent decisions, which leads them to report greater perceived enjoyment and competence compared to PE lessons delivered through traditional direct instruction [17]. New educational trends known as model-based practice or pedagogical models are gradually being implemented such as the Sports Education Model [18], the activist pedagogical model that aims to offer learning options and possibilities for all and challenge stereotypes [19] or student-centered research models as a curriculum that combines student and teacher actions, taking into account the voice of the students and the social construction of the content to be developed in the curriculum [20]. The teaching methodology by itself will not achieve greater effectiveness in student learning, that will also depend on the pedagogical skills and knowledge of the teacher and needs to be supported by a community of practice intent on improving learning across multiple domains in PE [21]. It is important that teachers generate self-reflection spaces and spaces where they can discuss and share experiences, challenges, and solutions on teaching–learning processes to encourage pedagogical change [22,23]. Evidence suggests that some teachers are trying to adopt a new model but are not succeeding in creating an appropriate learning environment. Consequently, the methodology cannot be seen as the only variable or as the most efficient one. Teachers often abandon new methodologies because they do not see the long-term benefits and they only want very short-term benefits [24]. On the contrary, teachers who work in a team find it easier to work on a new methodology, those who work in isolation tend to quit with the first difficulties. In any case, methodologies based on different models are now recommended, which allows a greater diversification in the functions of the teacher [25].

Collaborative work has often been used along with autonomy and decision-making strategies in the learning of gymnastic skills, as it enables the team to collaborate for a common purpose [26]. The team itself offers almost immediate feedback to its members and the contributions are interconnected and added up as has happened in other collaborative studies carried out in the context of physical activity and sport [26–28]. Likewise, in the gymnastic context, the collaborative work allows the reinforcement of the students' skills, increasing their satisfaction as well as their predisposition toward the gymnastic activities [29,30], enabling all-round competency development of the students [28]. Sharing responsibilities and persevering in facing and solving difficulties will allow them to learn in a more authentic context.

Based on this conceptual framework, the aim of this study was to assess a teaching intervention to support autonomy and collaboration as a means of achieving motivation and satisfaction in gymnastic learning through the analysis of students' reflective journals.

2. Materials and Methods

When we want to understand what the participants perceive, believe, feel, or experience, looking at meanings is the most appropriate, therefore the interpretive approach, usually called narrative or interpretative inquiry, is required [31]. PE research focus on themes such as motivation, resistance, perceived barriers, perceived competence, achievement expectations, or the level of self-regulation, which are examples of the various lines that can be investigated with interpretative approaches. The narrative inquiry approach allows the use of life stories as research data, since the personal narratives contain a force that give consistency to research [32].

This qualitative study had an intentional sample. We invited 38 students, aged 18–32 with a mean age of 19.92, SD = 2.869; from the 1st year of the bachelor's degree in Physical Activity and Sport Sciences (PASS) of the Spanish University, who enrolled the subject of Gymnastic and Artistic Skills. The selected participants had to attend all the practical sessions of the subject. The narrative design of the research has made it possible to analyze, through the voices of university students, their experiences in the field of gymnastics in their own educational context [33], which will make it possible to identify possible actions and changes in university training practices.

2.1. Design of the Teaching Intervention

The methodological design consisted of the development of 13 practical learning sessions of the mentioned subject, in which a strategy of support to the autonomy in collaboration was implemented. Researchers and teaching staff of the subject designed and planned the basic structure of the proposal prior to the intervention. During the development of the intervention, consultations and discussions were held with the students about the activities to be carried out, always in a climate of listening and exchanging proposals. The organization was of 6 groups of 6–7 students each. All students played three roles: performer, assistant, observer–reporter. After each practice, students conducted and handed out a reflective journal of the session focusing on two aspects: relevant experiences and difficulties. The learning process was carried out in 3 phases (initial, progress, final) (Table 1):

In the initial phase, the first four sessions of the subject, initial assessment of basic gymnastic skills was carried out and progression exercises were performed. Similarly, main errors were identified as well as the protocols for the support of these elements. In this phase, information was provided on the methodological operations, i.e., creation of work teams, distribution of spaces, methodology to be used, and the function of the journals.

In the progress phase, consisting of six sessions, we worked on progressions of acrobatics of greater technical difficulty such as the roundoff or the backward roll to handstand. We developed the acrobatic gymnastics and, finally, we reviewed and clarified doubts. In addition, students in their groups worked on the competence to identify errors, on the feedback, and on the aids in a collaborative way.

In the final phase, last three sessions, main activities were evaluative. In this phase, final tests were prepared in groups according to the needs and in a mutually supportive way. The only test of individual technical execution of the subject was performed, which could have been prepared with the help of the group, and a test of resolution of practical assumptions was carried out in which each student had to play the role of assistant and observer.

Table 1. Contents developed in the sessions of the analyzed gymnastic skills.

Sessions	Main Activities
Session 1 (initial phase)	Explanation of how the subject works. Diagnostic evaluation of individual performance: forward roll, backward roll, cartwheel, and handstand. Group formation and decision making in the work group to practice gymnastic motor actions by pairs, quartets, and sextets.
Session 5 (progress phase)	Practice of acrobatic skills in groups: Group and individual decision making for design, implementation, and error detection and correction of diverse gymnastic tasks (connection and acrobatic elements). Practice of activities associated with progression exercises to learn the backward roll to handstand and the roundoff (decision making and implementation).
Session 6 (progress phase)	Practice of acrobatic skills in groups: Decision making for the design and implementation of circuits with six stations. Practice of progression exercise activities to learn vertical flip, the backward roll to handstand, and the roundoff (decision making and implementation). Group design of an acrobatic gymnastics practice (decision making and implementation).
Session 7 (progress phase)	Practice in groups. Decision making and implementation for the performance, assistance and error detection in the cartwheel, the handstand, the roundoff, the backward roll to handstand, and the vertical bridge. Practical design of acrobatic gymnastics prior to the group practical test of this discipline in session 8. Design decision making and implementation.
Session 13 (final phase)	Final test of resolution of 4 practical scenarios of the competencies developed in relation to the assistant and observer role. Individual and group qualification.

2.2. Instrument

The instrument used for the data collection was a personal journal of each practice carried out. The personal journal as an instrument for qualitative research provides a wealth of information, allows a deep understanding of how people feel, and offers an important means of access to the rigorous study of educational processes [34].

Students were required to reflect after each session through a personal journal that revolved around the experiences of the session and the difficulties encountered during it. This journal was collected after each practice carried out. Students spent an average of 20 min completing their personal journal. Initially, 494 journals were collected. Finally, it was decided to only analyze 190 journals corresponding to sessions 1, 5, 6, 7, and 13 as they were the most representative of each phase, in the opinion of three experts in the subject under study.

Students were informed that the data from the personal journal could be used for research purposes. Informed consent was obtained, following the guidelines of the data protection law.

2.3. Procedure

The role of the researchers was to place themselves in the context of the participants, and to immerse in the observation and in the reading and interpretation of the class journal, to establish relationships between emerging keys of the narratives and conceptual framework that have guided the structure of the research. First, based on the selected journals, researchers made the first interpretative readings. Second, an initial categorization process was implemented that allowed the codes emerging from the students' narratives to be connected to the conceptual framework and research questions [35]. Then, we moved on to the discussion and validation of the inferential codes through a process of triangulation to establish their reliability. In this stage, two specialists in PE and a university professor expert in gymnastics intervened, validating the codes and the definitive categories. Once these processes had been completed, after repetitive approaches, the final categories and codifications of this study were identified:

Category I. Gymnastics learning: motivations and dissatisfactions.

I.1 Motivations and evolution of satisfaction experiences in learning gymnastics.

I.2 Motivations and evolution of dissatisfactions in the learning of gymnastics.

2.4. Data Analysis

The data have been analyzed using software AQUAD 7 [36]. The possibilities of this program have allowed us to organize the categories and codifications extracted from the students' reflections and thus to complement the qualitative analysis with a quantification. For this reason, we present, in the results, the code tables with the absolute frequency (AF) or number of findings regarding a concept and the percentage thereof (%AF).

3. Results

The results are organized according to the categories drawn from the research. In addition, some fragments of the students' journals are shown, which exemplify the analysis codes.

3.1. Category I. Gymnastics Learning: Motivations and Dissatisfactions

PASS students mostly identify their learning experiences as satisfactory whereas there is less emergence of dissatisfaction during learning (Table 2). According to the sessions analyzed, we found the most positive perceptions in session six (76.6%) and seven (69.3%), and we identified the experiences with the most dissatisfaction in session thirteen (58.1%), where a test for the resolution of practical assumptions was carried out.

Table 2. Perception of gymnastics learning, according to sessions.

Codes	Session 1		Session 5		Session 6		Session 7		Session 13	
	AF	%AF	AF	%AF	AF	%AF	AF	%AF	AF	%AF
Satisfaction	318	64.8%	325	64.6%	370	76.6%	359	69.3%	165	41.9%
Dissatisfaction	173	35.2%	178	35.4%	113	23.4%	159	30.7%	229	58.1%
Total	491		503		483		518		394	

AF: absolute frequency.

> As a performer, I felt very good about myself, I have mastered the handstand exercise, as well as other movements such as the cartwheel with one hand. In the past I could not perform them, now I just need to perfect them. I have loved the class, the circuit, combining all kinds of movements (Student_10_S6).

> After taking the exam, I was a little disappointed with myself, I failed some aids, this should have not happened (Student_37_S13).

As we observe in Figure 1, the satisfactions gradually increase until they reach the final test (Session 13) where the pressure of the assessment situation undoubtedly breaks their continuous and progressive motivation. Likewise, dissatisfactions decrease during the process. However, from Session 7 onward, the increasing oscillation of these dissatisfactions can be observed, possibly associated with the preparation of the acrobatic gymnastics test carried out in Session 8.

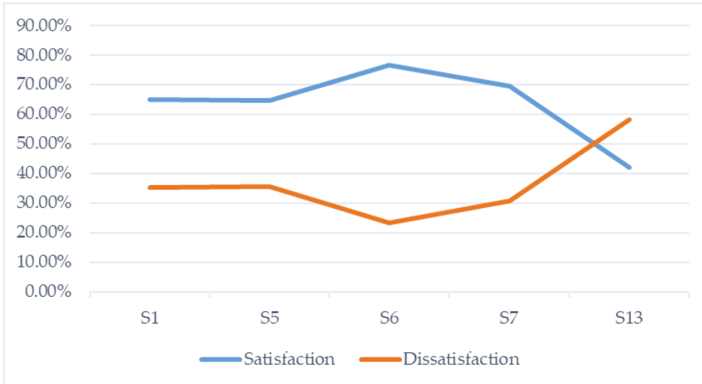

Figure 1. Evolution of the perceptions of satisfaction and dissatisfaction in the analyzed sessions of the teaching-learning gymnastic process.

3.1.1. Motivations and Evolution of Satisfaction Experiences in Gymnastics Learning

The satisfaction derived from the experiences (Table 3) is motivated by the gymnastic capacity that students perceive when they can perform the different activities proposed. This was particularly noticeable in sessions six (47%), seven (47.4%), and thirteen (46.7%). On the other hand, participants pointed out as a cause of satisfaction the working methodological proposal since it generates expectations of gymnastics learning, being more intense in session one (36.5%) and five (25.2%). Furthermore, the group's peers are a source of satisfaction, which is reflected by the bonds and support created with the class group. These motivations are especially visible in session six (25.3%) and seven (23.1%). Another cause of satisfaction perceived by students is in the decision-making process during the gymnastic tasks proposed. This is an opportunity offered to students to be able to manage their own process by solving diverse learning situations associated with the detection of errors, the design and practical application of progression exercises, or the implementation of aids, as appropriate. In this sense, a greater presence of this cause is perceived in session thirteen (21.2%) and seven (15.3%). Finally, and with less presence, there are reasons for satisfaction related to the teaching staff, with a greater presence in session six (4.2%).

Table 3. Motivations for satisfaction with gymnastics learning, by session.

Codes	Session 1		Session 5		Session 6		Session 7		Session 13	
	AF	%AF	AF	%AF	AF	%AF	AF	%AF	AF	%AF
Gymnastic competence	94	29.5%	124	38.2%	178	47%	170	47.4%	77	46.7%
Methodological proposal	116	36.5%	82	25.2%	49	13%	44	12.3%	33	20%
Classmates	69	21.7%	72	22.1%	96	25.3%	83	23.1%	16	9.7%
Decision making	28	8.8%	35	10.8%	40	10.5%	55	15.3%	35	21.2%
Teacher	11	3.5%	12	3.7%	16	4.2%	7	1.9%	4	2.4%
Total	318		325		379		359		165	

These satisfactions are reflected in the following excerpts from the students' journals:

> I performed the acrobatics quite well, I felt capable of improving in all those areas that helped to execute other exercises correctly. It is a very responsible role within this practice test as we had to perform the elements as best as possible (Student_09_S13).

> I ended up feeling happy, I left with the feeling that this is going to be a subject in which I can learn many things and I am going to do some other things that I would never have imagined (Student_37_S1).

I'm very happy, since the creation of this piece involves integrating a series of values such as trust, companionship, empathy, listening... and at the same time you have the opportunity to meet your peers in another of their facets. I am very comfortable with my team and I think we are going to do a good job (Student_02_S7).

Then they made us do another series with aids and it worked out better, they left us some time to decide how we were going to do the aids. I was very happy with how I had solved the problem (Student_24_S13).

I would highlight the inclusion displayed by the acrobatic gymnastics and the cognitive aspect that it involves. We must make our own choreographies, considering all the details when choosing music, costumes, figures. The importance of adjusting the safety guidelines or the artistic phase, among others (Student_08_S7).

I would like to point out something that I like very much in all the sessions, which is the positive reinforcement offered by the teacher with feedback comments. I am aware of my limitations, but she always congratulates us when we do something well and values our progress however small. That is to be thanked (Student_29_S6).

As we see in Figure 2, the reasons for satisfaction with a growing trend are the perceived improvement in their gymnastic competence, the bonds they create with their group classmates, and their ability to make decisions. On the other hand, we observe how the satisfaction with the methodological proposal decreases as the content develops and other achievements are accomplished, as we have mentioned. Teachers are not an indicator of satisfaction by themselves; their role is secondary due to the characteristics of the project in which the students are the main actors.

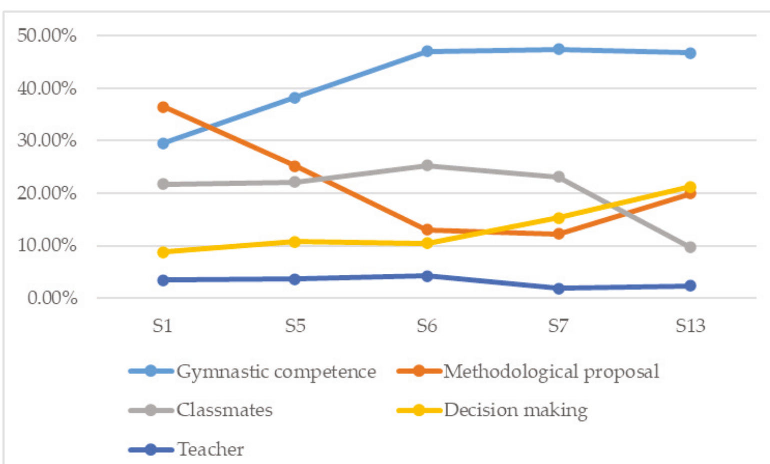

Figure 2. Satisfaction in gymnastics learning related to the perceptions about the learned gymnastic competence, the methodology proposal, the decision making, the classmates, and the teacher.

3.1.2. Motivations and Evolution of Dissatisfactions in Gymnastics Learning

The causes of dissatisfaction indicated by the university students throughout the process of learning gymnastics (Table 4) were, among others, the deficiencies in the skills presented and the gymnastic incompetence that they felt especially in the fifth (59%) and sixth sessions (56.6%). Moreover, they have pointed out as negative causes, the lack of confidence, the fear, frustration, and perceived anxiety during the sessions held, especially in the initial (34.1%) and final sessions (59.9%). Group classmates are also mentioned with a negative perception. Lack of support or commitment from their peers has been reported, although with less presence. This perception was especially displayed in the seventh session (10.7%) and in the initial session (10.4%). To conclude, the muscular discomfort perceived especially in session five (7.9%) and seven (7.5%) together with the dissatisfaction with the teachers, exclusively in session thirteen (1.3%) are causes minimally mentioned.

Table 4. Motivations for dissatisfaction in gymnastics learning, by session.

Codes	Session 1		Session 5		Session 6		Session 7		Session 13	
	AF	%AF	AF	%AF	AF	%AF	AF	%AF	AF	%AF
Gymnastic incompetence	79	45.7%	105	59%	64	56.6%	79	49.7%	68	29.7%
Fear and anxiety	59	34.1%	33	18.5%	23	20.4%	37	23.3%	137	59.9%
Lack peer support	18	10.4%	18	10.1%	0	0%	17	10.7%	12	5.2%
Physical discomfort	6	3.5%	14	7.9%	5	4.4%	12	7.5%	5	2.2%
Teachers	0	0%	0	0%	0	0%	0	0%	3	1.3%
No dissatisfaction	11	6.3%	8	4.5%	21	18.6%	14	8.8%	4	1.7%
Total	173		178		113		159		229	

Below are excerpts from the students' journals that reflect these dissatisfactions:

I keep improving the cartwheel, as I started from scratch and I have never been able to do it before. It's very hard for me and I have difficulty in the roundoff. In the handstand, I lack more security in the gesture and some physical condition (Student_04_S5).

I find the roundoff complicated because of the position of the hands and the end with the corvette, since I end up doing the cartwheel or I don't manage to raise my legs completely (Student_23_S6).

I felt a little afraid at first during the initial level test, due to the uncertainty of not knowing (Student_34_S1).

I got nervous during the exam and lacked responsiveness. Due to these nervousness, I have made very absurd mistakes that I don't usually make, for example in the aid of the forward roll I have blocked myself and I haven't been able to do it well until I managed to calm myself down (Student_26_S13).

At the end of the class we were given some time to get organized in the acrobatic gymnastics' activity, where I could not execute any figure because most of my group was not there (Student_20_S7).

I have observed that my classmates had similar difficulties with the execution of the project, which did not help us at all, and that some of them lacked initiative in acting and helping (Student_10_S1).

Quite dissatisfied with the completion of the bridge as I can't get it done. Also, it causes me a lot of pain in my lumbar area (Student_18_S7).

I think we should have been tested some other time during the term, to be able to deal with the insecurity and pressure that such a situation automatically causes (Student_02_S13).

It should be noted that there are student statements that specify no reason for dissatisfaction and that this was most noticeable in session six (18.6%) and in session seven (8.8%).

Today's session went very smoothly and without any problems. At first, I was fine while we were practicing (Student_03_S6).

As we can see in Figure 3, at the beginning of the learning process, dissatisfaction grows due to the deficiencies and difficulties in performing gymnastic tasks. This perception begins to diminish after the fifth week of work and is less visible in the last weeks of training. On the other hand, the causes of dissatisfaction associated with anxiety, fears, or frustration decrease progressively until the exam preparation period begins, and they become exponentially accentuated in the final sessions where students were immersed in the evaluation process.

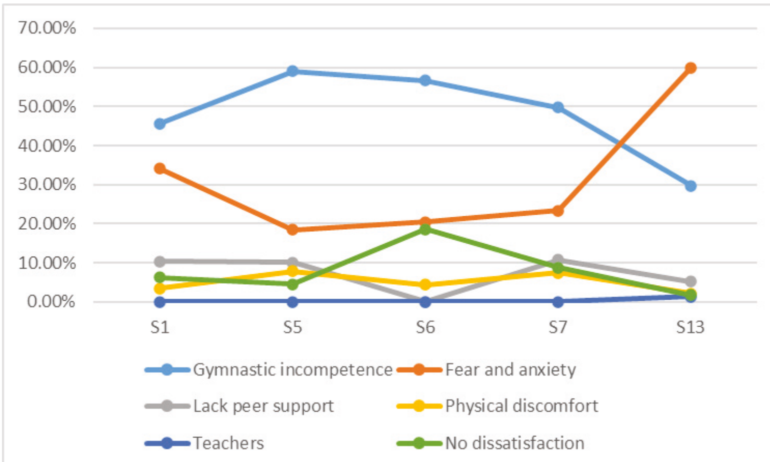

Figure 3. Dissatisfaction in gymnastics learning related to the perceptions about the gymnastic competence, fears and anxiety, lack of peer support, physical discomfort, teacher, and no dissatisfaction.

We would like to stress that in the middle weeks participants reach their maximum in the non-perception of dissatisfaction, which decreased toward the end of the process.

4. Discussion

The appreciation of the methodological strategy is highly valued by the students when the teacher proposes it at the beginning, but during the process the references to the proposal decrease and, in their journals, they focus more on the specific variables. The lack of motivation with the methodological proposal is not present in the narratives either. These assessments are built from the opportunities offered by the group work allowing students to experience different roles in their learning. Not only is the performance of the acrobatic elements fundamental, but it is also important to highlight the observation of peers for the identification and correction of errors, in addition to offering direct assistance in the performance of the different tasks. We agree with O'Leary and Griggs [28] on the importance of sharing responsibilities and developing a social and emotional maturity allowing them to teach and learn from each other. Likewise, offering control situations in activities and training the self-control in high-pressure scenarios will guarantee less anxiety in students, especially when the evaluation is more latent and is presented as a challenge and not as a threat [37], just as it can happen in sports competitions where it is important to focus on the problem situation and seek support from others [38,39].

This can contribute to quality training not only on a technical level, but also to develop strategies for students to overcome obstacles and tools to cope with difficulties thanks to reflective and collaborative work, among other factors [40,41].

We can confirm that students reflect positively on the mastery and progression of their gymnastic skills since, in relation to the evolution of the specific variables of motivation, gymnastic competence grows from the initial session to the last. However, the highest percentage appears at the halfway point of the development of the strategy where there was no pressure on the task. In this regard, learning during teacher training from one's own practical experience will be able to connect optimal teachings in one's professional future [42]. On the other hand, the dissatisfaction with the gymnastic achievements grows during the first sessions due to the perception of difficulty in the proposed tasks, which can cause anxiety, stress, and insecurity in the movements, especially in the initial phase of the process. The feeling of being overwhelmed and other negative emotions diminish during the entire phase of progress until the end of their training, except for the last session where they emerge again. It is quite clear that the perceptions during the trajectory change [23] and the reasons for the change happen when the tasks become more difficult, and when they must prepare actions that require a performance. The emotional states that come with gymnastics learning must be considered since they are decisive for the technical acquisition and the cognitive stage of the learning process, especially in the first phases of gymnastics learning [43]. Several studies on frustration and dissatisfaction [44,45] have shown that the causes of dissatisfaction may lie in the lack of communication, lack of organization in the task, and lack of integration in the team, in addition to the initial lack of motivation as a result of the difficulties. In our analysis, we sought the above-mentioned elements.

The peer support variable progresses from the beginning to drop abruptly in the assessment session of the practice resolution where they preferred not to seek peer support. Their reflections are generally positive, although they refer more to issues of collaborative work than to expressions of enjoyment of a socially shared space. To some extent this diverges from the findings of Subramaniam and Silverman [46], who concluded that students' enjoyment and their attitudes toward the practice would be enhanced if they were provided with a more suitable learning environment and added that in this way students are more likely to enjoy their experiences and maintain their intrinsic motivation. One would expect, according to many research studies that enhance the strength of socialization [39,47], that the need for relationships makes people highly motivated to be acknowledged. Therefore, between the control and support for autonomy, the support of the group predicts greater satisfaction in people because of their relational power.

In the variable of the teacher support, there are not many allusions since the collaborative strategy carried out favors the autonomy, the interrelationship between students, and their direct involvement in the development of the gymnastic activities. Therefore, students have been autonomous, and the teaching role remains in the background, with their function being limited to observing, offering feedback, helping, and evaluating [48]. Their role is not so directive nor is it a protagonist in the learning scenario.

Autonomy and decision making are the only variable evolving upward during the entire process, although it is a rare category, probably because in the last evaluation session they necessarily had to make their own decisions. There is no statement expressly indicating resistance to autonomy or decision making. Although, is the appreciation of this opportunity was also not enhanced. This fact to some extent contradicts the perspectives that predict autonomy as a student need. We could dare to make some hypotheses to be confirmed in further studies. In this line, it is necessary to point out that the decision-making process of students in training is constantly changing as there are many factors that can influence this process such as the context or the cultural background of the students [23]. The Spanish university system grants considerable autonomy to the student by promoting the principles of European Convergence in the European Higher Education Space-EEA [49]. In primary education, even in secondary education, constructivist and innovative principles have been fully and deeply embraced in the methodological space of teaching and learning. This may mean that students, right from the start of their studies, are guaranteed a certain amount of autonomy.

Even though there are numerous investigations in which the student shows his or her lack of motivation due to the inadequate methodology of the teaching staff [50], our experience in university teaching, and in research in the context of higher education, has shown us, on the contrary, that frequently our students of Physical Activity and Sport Sciences are quite flexible and sometimes react to the most innovative methods because they demand more effort than a conventional methodology. There are many students in first and second year of the bachelor's degree who prefer more traditional methods as shown by the fact that master class format methodologies are rated positively in student satisfaction surveys. It is essential that teaching staff create spaces where they can share continuous actions and reflections with their students so that they can respond pedagogically to the needs and interests of a diverse student population [22,23].

In this case, the reflections in the class journal were maintained and did not diminish neither were they abandoned even in the moments of evaluation. This shows that communication and reflection strategies whether journals, self-talk [51] or think-aloud [52], and narrative interviews [53] are all working. Ekkekakis and Brand [54] insist that knowing how people feel when they are learning, and practicing is important to predict their perseverance. However, the "I feel better" effect is not always predictive, since emotional and affective responses are complex and past experiences can negatively influence on the perception of difficulty as can social, physical, and organizational or performance stressors [19,55]. Obviously, interpretive research requires the researcher to have dialogue, listening, and a reflective mood. Researcher must know and experience the context of the research to be able to interpret the information from a situated perspective. The interpretative perspective has been shown to be appropriate in this study in which researchers were also situated in the participants scenario. In short, seek deep meaning and make sense of experiences as Morse [56] stated; it is a promising innovation in PE.

Finally, we noted in the participants' narratives that the strategy was useful and worth implementing. Our research has started from understanding that the implementation of an innovation strategy is to undertake a journey together with our students so that we can see their difficulties in each step, know them first-hand, and bring innovation in co-participation, in the same space and time. We can say that all researchers, teachers, and students have experienced innovation from within. We know about the gap that exists between research and applications, and we think that to bring together theory and action, we need a real immersion in the situation and in the path of innovation. However, within the limits of the study, the sample could be extended and variables that could influence the process such as the teaching staff or the gender of the students [19,24], as well as previous experience in this type of skills, could be analyzed. In our future lines of research, we plan to design, implement, and analyze methodological strategies that will allow us to manage the states of stress and anxiety of students at different times of the initial, continuous, or final assessment. Carrying out simulated test practices, role-playing that brings students closer to the type of test, and providing spaces for dialogue to share experiences of passing exams could be useful strategies to consider for future educational interventions.

5. Conclusions

From the beginning of the Gymnastic Skills subject, and after knowing the objectives and the learning process, students showed in their reflection's good expectations and motivations, related to the learning strategy and the expected achievements. In the first and second phase, satisfaction grew while difficulties diminished. The experiences shared focused on the students' satisfaction with respect to their competence and self-confidence, while controlling their fears and insecurities. The methodology was highly valued for offering them freedom, companionship, and competence, although some narratives reflected disagreements within the group and some difficulty. The problem, unexpected to a certain extent by the teachers, was the decrease in motivation and satisfaction due to not having enough skills to control the pressure of the final tests. Teachers should strive to create environments that are task-oriented, motivating, goal-oriented, and reflective in terms of self-perception of the ability to work under pressure, so that students will be more involved in the process of their learning, and their performance will be more effective.

In summary, we conclude that further research is needed on the above strategies to prevent learning under pressure from affecting and counteracting the results of an autonomous and collaborative learning process. We also hope that we have contributed modestly to the research on how to apply and implement perspectives to improve teaching and learning in a real and authentic context.

Author Contributions: All of authors contributed substantially to be conceptualization and design of the study; data curation, M.A.Á.-R.; formal analysis, M.A.Á.-R. and M.Á.M.R.; methodology, M.A.Á.-R. and M.Á.M.R.; writing—original draft, M.A.Á.-R. and M.Á.M.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: We want to and must thank students for giving their consent to be able to use their class journals anonymously.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

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Review

HRV-Based Training for Improving VO_2max in Endurance Athletes. A Systematic Review with Meta-Analysis

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Received: 29 September 2020; Accepted: 28 October 2020; Published: 30 October 2020

Abstract: This review aimed to synthesize evidence regarding interventions based on heart rate variability (HRV)-guided training for VO_{2max} improvements in endurance athletes and address the issues that impact this performance enhancement. The Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, CINAHL Complete, the Web of Science Core Collection, Global Health, Current Contents Connect, and the SciELO citation index were searched. Inclusion criteria were: randomized controlled trials; studies with trained athletes enrolled in any regular endurance training; studies that recruited men, women, and both sexes combined; studies on endurance training controlled by HRV; studies that measured performance with VO_{2max}. A random-effects meta-analysis calculating the effect size (ES) was used. Moderator analyses (according to the athlete's level and gender) and metaregression (according to the number of participants in each group) were undertaken to examine differences in ES. HRV-guided training and control training enhanced the athletes' VO_{2max} ($p < 0.0001$), but the ES for the HRV-guided training group was significantly higher ($p < 0.0001$; $ES_{HRVG\text{-}CG} = 0.187$). The amateur level and female subgroup reported better and significant results ($p < 0.0001$) for VO_{2max}. HRV-guided training had a small (ES = 0.402) but positive effect on endurance athlete performance (VO_{2max}), conditioned by the athlete's level and sex.

Keywords: performance; heart rate variability; high-level athletes; maximal oxygen uptake

1. Introduction

1.1. Description of the Condition

The key components in any training program are the volume (i.e., how much), intensity (i.e., how hard), and frequency (i.e., how often) of the exercise sessions, and the combination of these 'training impulses' determines the magnitude of adaptive responses that improve the physical condition of an athlete or increase fatigue [1]. Combining these key elements to optimize training in athletes for better performance represents a relevant area of research within exercise physiology and sports medicine [2]. It is recognized that a standard training program applied to a group of athletes can induce diverse responses in terms of performance and physiological adaptations [3,4]. Therefore, individualization is recognized as a training principle [1] as well as the need to adjust training stimuli to the psychophysical load capacity and individual tolerance of each athlete, if individual responses to training and recovery loads are intended for optimal performance [5]. The maximal oxygen uptake (VO_{2max}) is considered one of the main indicators for measuring an athlete's performance and cardiovascular adaptation to training loads [6]. The VO_{2max} is defined as the largest volume of oxygen that the body can capture, use, and transport during intense exercise [7] and is a determining factor of endurance performance [7,8]. As Vesterinen et al. [4,9] state, although some athletes show great endurance performance improvements after standardized group training (even up to 40% in VO_{2max}), other athletes show no changes or benefits, and sometimes even show a decrease in endurance performance. In recent years, research has looked at whether heart rate variability (HRV)-guided training has positive effects on athletic performance, given that this type of training allows daily adjustment of the training and recovery stimuli, individually based on HRV records [4,5,10].

1.2. Description of the Intervention

HRV is an indicator that enables the noninvasive analysis of autonomic nervous system activity in both its sympathetic and parasympathetic branches [11]. This is relevant if we consider that an important component of the interindividual variability in physiological responses to training is related to the balance between the parasympathetic (PNS) and sympathetic (SNS) activity of the autonomic nervous system (ANS) [12]. According to Huang et al. [13], HRV is considered the variation in the time interval between two consecutive heartbeats and obtained by calculating the time interval between two consecutive R waves (i.e., RR interval fluctuation) in the electrocardiogram (ECG). Since the elapsed time between beats is not constant, high vagally related HRV values are associated with efficient ANS, promoting behavioral adaptation and cognitive flexibility during stress [14], while low HRV is indicative of an inefficient ANS, resulting in maladaptive responses to stress and perceived threats [13]. HRV analysis is considered a useful method for measuring the heart's ability to adapt to endogenous and exogenous loads [15]; therefore, it can be used for the individual assessment of responses to training loads and recovery adaptation [4,16]. High HRV measurements indicate more parasympathetic than sympathetic activation, which is indicative of better recovery and preparedness for facing high-intensity training sessions [17]. HRV-guided training starts with a preparation period of about four weeks, which serves as a standardized data collection phase to obtain the baseline HRV values (e.g., LnrMSSD; the natural logarithm of the square root of the mean value of the sum of the squares of the differences between the adjacent RR intervals) and their normal range (upper and lower limits) for each athlete [9,18]. Once the normal range of HRV measurements has been established, the training prescribed (moderate- or high-intensity session) is based on this calculation, which is normally updated weekly [19]. Traditionally, the vagally related HRV index has been measured with ECG [20], and quantified by means of rMSSD [17]. Currently, the development and validation of new applications (i.e., smartphone applications: Kubios-HRV, Elite-HRV, Mobile Lab, or HRV4Training) facilitate daily HRV measurements and their quantification and, thus, the individual adaptation of training loads and recovery.

1.3. How the Intervention Might Work

Bellenger et al. [21], in a recent systematic review with meta-analysis, highlighted the need to use monitoring systems that accurately reflect the athletes' adaptations to the training stimulus. Although there have been numerous research studies using the HRV measure to check wellness and training adaptation in athletes [22,23], these have not focused on performance improvement based on HRV-guided training but have followed training interventions based on a traditional and nonindividualized methodology.

In contrast, evidence exists supporting the use of HRV-guided training for improved performance in endurance athletes. With this type of training monitoring, some studies have found significant VO_{2max} improvements in athletes who have developed individualized endurance training programs based on daily HRV values. These studies alternated moderate-intensity sessions with high-intensity sessions [4,10] or even rest sessions, vigorous-intensity training, and moderate-intensity exercise [5].

However, Javaloyes et al. [18], in a program with similar characteristics developed with professional cyclists, found no significant improvements in VO_{2max}. Likewise, significant improvements have been found among athletes following HRV-guided training in other variables; for example, for lactate in maximal test [10], speed in maximal test [4], time in maximal test [4,10], or muscle strength [24]. At the level of perceived recovery, significant improvements have also been found in variables such as general stress, emotional stress, lack of energy, and even overall mood disturbance [25]. HRV-guided training may, therefore, function as an alternative method for improving performance in resistance athletes.

1.4. Why Is This Review Important?

In the search to improve athletic performance, different training methods have been tried and studied, such as intensified training [2] or submaximal tests [26]. However, it has also been recognized that the same training program followed by a group of athletes can provoke a wide range of reactions in terms of performance and physiological adaptations [3]. Overuse injuries occur due to repetitive submaximal loading of the musculoskeletal system when there is inadequate rest to allow for structural adaptation to take place [27]. In recent years, HRV-guided training has shown itself to be a promising method for improving different performance variables (e.g., VO_{2max}) compared to predefined training (traditional training) through the monitoring and individualization of endurance athletes' training [4,28]. HRV-guided training has been investigated in randomized trials on samples from different endurance sports, such as skiers [28], runners [4,25], and cyclists [18]), as well as athletes of different ages and levels: elite [18,28] and recreational endurance athletes [5,24,25]. Therefore, it is important to carry out a systematic review and meta-analysis of the different experimental studies conducted so far on endurance athletes in order to assess whether HRV-guided training is an effective method for performance improvement.

2. Objectives

As mentioned above, this review aimed to analyze the effect of HRV-guided training on VO_{2max} in endurance athletes.

We asked the following research questions regarding HRV-guided training in endurance athletes:

Research Question 1: Does HRV-based training have an effect on VO_{2max}?
Research Question 2: Is the effect of this type of training superior to that of traditional training?
Research Question 3: Is the level of the athletes decisive in obtaining an effect on the VO_{2max}?
Research Question 4: Does the effect of HRV-guided training determine VO_{2max} scores according to the gender of the athlete?

3. Methods

The methods detailed below are reported in accordance with the Campbell Collaboration policies and guidelines for systematic reviews [29].

3.1. Criteria for Considering Studies for This Review (Eligibility Criteria)

3.1.1. Types of Studies

We included randomized controlled trials (RCTs) and the first period of cross-over RCTs and experimental studies using a random method for the treatment assignment in order to reduce the risk of allocation bias. We restricted study eligibility by language. We did not restrict study eligibility by publication status.

3.1.2. Types of Participants

We included studies with trained athletes enrolled in any form of regular endurance training (e.g., runners, triathletes, skiers, and cyclists). We included studies that recruited both men and women, or men and women separately.

3.1.3. Types of Interventions

We included studies on endurance training controlled by heart rate variability to improve the athletes' performance. We considered designs comprising any dose, frequency, and duration. We also considered studies with the following types of comparisons:

- Endurance training controlled by HRV versus no specific training intervention (e.g., habitual physical activity).
- Endurance training controlled by HRV versus another training intervention (e.g., traditional endurance training or another type of traditional training).
- Endurance training controlled by HRV versus another training intervention (i) versus a further training intervention (ii).
- Endurance training controlled by HRV (i) versus endurance training controlled by HRV (ii) versus another training intervention versus no specific training intervention.

3.1.4. Types of Outcome Measures

- Primary
    - Maximal oxygen consumption (VO_{2max})

3.2. Search Methods to Identify the Studies

3.2.1. Electronic Searches

The register contains studies identified from the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, CINAHL Complete, the Web of Science Core Collection, Global Health, Current Contents Connect, and the SciELO citation index.

The search is up to date as of 15 June 2020. The language was restricted, considering only English or Spanish. The terms used to search the databases were: (*amateur* OR *elite* OR *train**) AND (*HRV-guided* OR *"heart-rate variability guided"*).

3.2.2. Searching Other Resources

We checked the reference lists of all the included studies and systematic reviews for additional references. We contacted experts in the field and the authors of the included studies to identify additional unpublished studies. We also checked the results of completed trials registered on the US National Institutes of Health Ongoing Trials Register, ClinicalTrials.gov, the World Health Organization International Clinical Trials Registry Platform (WHO ICTRP), and proceedings of conferences for relevant research.

3.3. Data Collection and Analysis

We conducted the following data collection and analysis in accordance with the recommendations in the Cochrane Handbook for Systematic Reviews of Interventions [30].

3.3.1. Selection of Studies

Two review authors independently screened the titles and abstracts of all the retrieved references in Microsoft Excel 2018 (Microsoft, New York, NY, USA) for Windows. The full-text study reports were retrieved for all the citations that at least one review author considered potentially relevant. Two review authors independently screened the full-text articles and identified studies for inclusion; they also identified and recorded the reasons for excluding studies in the excluded studies characteristics. Any disagreements were resolved through discussion. The selection process is detailed in a PRISMA flow diagram [31].

3.3.2. Data Extraction and Management

We used a standardized piloted data collection form in Microsoft Excel 2018 for Windows and extracted the following study characteristics and outcome data: (i) Methods: study design; (ii) Participants: randomized number, study participants' mean age or age range, study location and setting, recruitment methods, inclusion and exclusion criteria, and type of endurance sport; (iii) Interventions: a description of the training intervention characteristics, the dose and duration of the training intervention, a description of the comparison intervention characteristics, the length of follow-up, the number of withdrawals, and the reasons for withdrawal; (iv) Outcomes: a description of the primary and secondary outcomes in the review that were reported in the trial and a listing of other outcomes collected in the trial; (v) Notes: the trial funding and notable conflicts of interest of the trial authors; (vi) a 'risk of bias' assessment. Two review authors independently extracted the outcome data from the included studies into Microsoft Excel 2018 spreadsheets and compared the data to identify any discrepancies in the data entries. Any disagreements were resolved by consensus. In the Characteristics of Included Studies section, we noted down if a trial did not report outcome data in a usable way. We then transferred all the outcome data into the Comprehensive Meta-Analysis software version 2.2.064 (Biostat, Englewood, NJ, USA) [32].

3.3.3. Risk-of-Bias Assessment in the Included Studies

Two review authors (M.C.P., A.G.G.) independently assessed the risk of bias for each included trial using the Cochrane risk-of-bias tool [30]. Any disagreements were resolved by discussion. The risk of biases were assessed for the following domains: random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment for each outcome (detection bias), incomplete outcome data (attrition bias), selective outcome reporting (reporting bias), and other biases (such as the validity of outcome measure and baseline comparability). Each potential source of bias was assessed as either high, low, or unclear, and a quotation from the study report was provided together with a justification for the judgment in the 'risk of bias' tables. The judgments across the different studies were summarized for each of the domains listed.

3.3.4. Treatment Effect Measures

The outcome data for each study were uploaded into the data tables of the Comprehensive Meta-Analysis software to calculate the treatment effects. We used the mean difference (MD) for continuous outcomes reported on the same scal, and the standardized mean difference (SMD) for continuous outcomes measured on different scales in different trials ($SMD = M_{HRV\ guided\ training} - M_{control\ group}$/Standard deviation) [33]. Uncertainty was expressed with 95% confidence intervals (CIs) for all the effect estimates.

3.3.5. Assessment of Heterogeneity and Reporting Bias

Heterogeneity was assessed qualitatively between studies in three ways: a visual examination of the forest plots, the Chi^2 test ($p \leq 0.10$) for heterogeneity, and the I^2 statistic. The implications of the observed I^2 statistic value were considered as follows: 0% to 40%—might not be important; 30% to 60%—may represent moderate heterogeneity; 50% to 90%—may represent substantial heterogeneity; 75% to 100%—considerable heterogeneity [30]. Publication bias was assessed by examining the asymmetry of a funnel plot using Egger's test. If studies were distributed symmetrically around the mean effect size (ES), there was an absence of publication bias [33]. Subgroup analysis was carried out using the outcome for athlete level (elite vs. amateur) and sex (men, women, and both sexes combined). Metaregression was used to assess the relationship between the studies and the variable sample size.

3.3.6. Sensitivity Analysis

A sensitivity analysis was carried out to check whether the results varied according to the endpoint data.

4. Results

4.1. Description of the Studies

4.1.1. Search Results

The search produced a total of 36 studies, with 222 additional records identified through other sources. The removal of duplicates resulted in eleven studies, which were screened by the two authors based on the title and abstract. Three studies were excluded. Eight full-text articles were assessed for eligibility. Two more studies were excluded, and six studies were included either in the qualitative analysis or in the quantitative metasynthesis. The PRISMA flow chart illustrates the search and selection process (Figure 1).

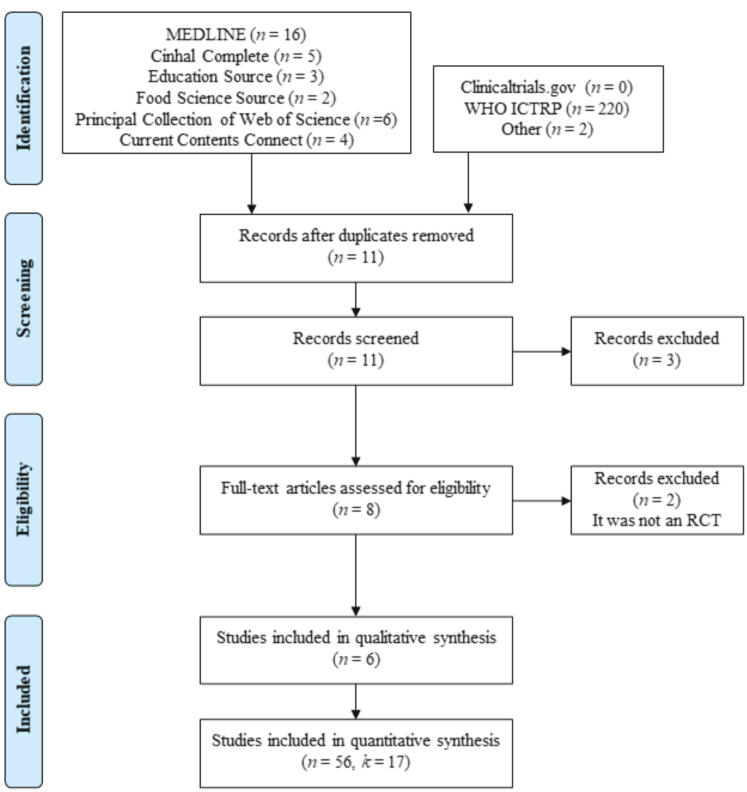


Figure 1. Study flow diagram following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Guidelines [31], where n is the number of papers and k is the number of individual studies.

4.1.2. Included Studies

Six studies carrying out HRV-guided training with elite or amateur athletes were included in this review [4,5,10,18,19,28], which were identified by the first author and publication date: Javaloyes_2019, Kiviniemi_2007, Kiviniemi_2010, Nuuttila_2017, Schmitt_2018, and Vesterinen_2016.

- Study location

Schmitt_2018 conducted their study at the French National Ski-Nordic Center, while the locations for the other five studies were not specified.

- Study design

Every study included in this review was a randomized controlled trial.

- Participants

A total of 195 participants (134 men and 61 women) were included in these studies. Kiviniemi_2007, Javaloyes_2019, and Nuuttila_2017 considered only male samples of 30, 17, and 32 participants, respectively. In the rest of the studies, the samples were composed of men and women: Kiviniemi_2010 included 24 men and 36 women, Schmitt_2018 incorporated 19 men and 5 women, and Vesterinen_2016 assessed 20 men and 20 women. In the studies by Javaloyes_2019 and Schmitt_2018, the samples were composed of professional athletes (cyclists and Nordic skiers, respectively) while in the other four studies, the samples were of a nonprofessional level.

- Interventions

According to the types of comparisons contemplated in the present systematic review ((a) endurance training controlled by HRV versus no specific training intervention; (b) endurance training controlled by HRV versus other training intervention; (c) endurance training controlled by HRV (i) versus another training intervention (ii) versus another training intervention; (d) endurance training controlled by HRV (i) versus endurance training controlled by HRV (ii) versus other training intervention versus no specific training intervention. Kiviniemi_2007, Javaloyes_2019, Nuuttila_2017, and Vesterinen_2016 were classified in Comparison B, Schmitt_2018 in Comparison C, and Kiviniemi_2010 in Comparison D.

The interventions in the included studies focused on running (Kiviniemi_2007, Kiviniemi_2010, Nuuttila_2017, and Vesterinen_2016), skiing (Schmitt_2018), and cycling (Javaloyes_2019). They were from 6 to 15 weeks long. In most of the studies, three (Nuuttila_2017) or four (Javaloyes_2019, Schmitt_2018, and Vesterinen_2016) low-intensity preparation weeks were followed either by the experimental or control groups (standard training) before the intervention. An eight-week intervention was carried out in Javaloyes_2019, Kiviniemi_2010, Nuuttila_2017, and Vesterinen_2016, whereas Kiviniemi_2007 considered four weeks of training and Schmitt_2018 15 days. The assessment weeks were treated separately from the intervention period in Javaloyes_2019, Kiviniemi_2007, and Schmitt_2018.

In every study, the experimental groups trained at moderate or high intensities according to their daily HRV scores. The control groups (standard training) followed a predefined training design at high, moderate, and low intensities (Javaloyes_2019), high and moderate intensities (Kiviniemi_2010 and Nuuttila_2017), high and low intensities (Kiviniemi, 2007) or moderate and low intensities (Vesterinen_2016). The control group (standard training) design was not explained in Schmitt_2018.

- Outcomes

The primary outcome analyzed in the included studies was VO_{2max}. The secondary outcomes were: ventilatory thresholds (Javaloyes_2019, Kiviniemi_2007) and power in the cycling test

(Javaloyes_2019); rMSSD or RR interval (Javaloyes_2019, Kiviniemi_2007, and Schmitt_2018); basal heart rate (Nuuttila_2017, Kiviniemi_2010, and Schmitt_2018); maximal heart rate in the ergometer test (Nuuttila_2017); speed in the treadmill test (Kiviniemi_2007, Nuuttila_2017, and Vesterinen_2016); maximal speed in the 10 m test (Nuuttila_2017); time and lactate in the 3000 m test (Nuuttila_2017); maximal load in the ergometer test (Kiviniemi_2007 and Kiviniemi_2010); and oxygen saturation and VO_2 at the second ventilatory threshold (Schmitt_2018).

Further details about participants, interventions, comparators, and outcomes are provided in Table 1.

Table 1. Overview of the studies included in the review.

Author, Year	Method	Participants	Intervention	Outcomes	Results	Risk of Bias: Bias	Risk of Bias: Author's Judgment	Risk of Bias: Support for the Judgment
Javaloyes_2019	Randomized controlled trial	Trained male cyclist, mean age of 38.42 years. N = 17: EG = 9 + CG = 8 Location: not specified. Recruited from local clubs Inclusion criteria: at least 2 years of experience in cycling. Exclusion criteria: not specified.	15 weeks (4 weeks of baseline period to capture baseline HRV + 8 weeks of training + 3 weeks of assessments); 4–7 sessions/week; time depended on the training intensity. EG: HRV-G-based training before each session; training MICT and HIIT according to HRV. CG: 4 high-intensity training sessions + 4 high-intensity interval training sessions + 6 moderate-intensity training sessions + 2–5 low-intensity training sessions/week. No follow-up periods. No withdrawals	Primary: VO_{2max} (maximal bicycle ergometer test, direct measurement). Secondary: ventilatory thresholds in the graded test, peak power output in the graded test, rMSSD with a heart rate monitor + kubios (LnrMSSD) in a supine position for 90 s, mean power output during a 40 min all-out cycling test.	VO_{2max}: no significant differences between intragroups and intergroups. Moderate training load: significant intergroup differences (EG = 24%; CG = 27%). VT2: significant improvements in EG (36.11 ± 3.73W). Peak power output: significant improvements in EG (17.45 ± 3.91W). LnrMSSD: significant differences between intergroups for the percentage of change (EG = 0.85 ± 3.21%, CG = −2.02 ± 5.21%). Mean power 40M: significant improvements in EG (17.67 ± 3.03W)	Selection	Unclear	Insufficient information about the sequence generation process and allocation to permit judgment of 'low risk' or 'high risk'.
						Performance	High	Incomplete blinding, and the outcome is likely to be influenced by lack of blinding.
						Detection	Unclear	The study did not address this outcome.
						Attrition	Low	No missing outcome data.
						Reporting	Unclear	Insufficient information to permit judgment of 'low risk' or 'high risk'.
						Other	Low	The study appears to be free of other sources of bias.
Kiviniemi_2007	Randomized controlled trial	30 healthy recreational male runners N = 30: TRA: predefined training group (n = 10) + HRV: HRV-guided training (n = 10) + CG: Control group (n = 10). Location: Not specified Recruitment: The candidates were interviewed with a standardized scheme to ascertain their medical history and levels of physical activity. Inclusion criteria: healthy men. Exclusion criteria: subjects who had done regular physical exercise training less than twice a week for the past 3 months, competing athletes, and subjects with diabetes mellitus, asthma, or cardiovascular disorders were excluded.	6 weeks: 1-week baseline resting + pretest Intervention: 4-week training period (6 days per week) consisting of running sessions at either a low- or high-intensity level according to recommendations by the American College of Sports Medicine: low-intensity: 40 min of jogging at 65% of maximal HR; high-intensity exercise included 5 min warm-up and cool-down periods at 65% of the maximal HR before and after 30 min of running at 85% of maximal HR. The last week for the post-test. HRV: exercised at low- or high-intensity or rested based on their daily HRV measurements at home. If HRV increased or did not change, vigorous-intensity training on that day. If HRV decreased, moderate-intensity exercise or rest. TRA: weekly training started with low-intensity exercise followed by two sessions of high-intensity exercise on successive days. This 3-day period was repeated before a day of rest. CG: no intervention No follow-up period. 4 withdrawals: TRA (2); HRV (1); CG (1).	Primary: VO2peak (maximal treadmill ergometer test: direct measurement). Secondary: high-frequency power of RR interval with software while standing for 5 min, maximal load in the ergometer test, maximal running velocity in the ergometer test; ventilatory threshold (VT) from the relation of running velocity and selected ventilatory parameters.	VO2peak: significant intragroup improvements in the HRV group (pretest = 56 ± 4; post-test = 60 ± 5 mL/kg/min). High-frequency power of RR interval: significant intragroup improvements in TRA (pretests = 4.7 ± 0.4; post-test = 5.5 ± 0.8 ln ms^2), and HRV (pretests = 4.8 ± 0.6; post-test = 5.2 ± 0.8 ln ms^2). Maximal load: significant intragroup improvements in TRA (pretest = 15.1 ± 1.3 km/h; post-test = 15.7 ± 1.2 km/h); significant intergroup differences between CG (post-test = 14.9 ± 1.5 km/h) and TRA (post-test = 15.7 ± 1.2 km/h), TRA and HRV (post-test = 16.4 ± 1.0 km/h), and between CG and HRV. VT: significant intragroup improvements in HRV (pretest = 12.2 ± 0.6 km/h; post-test = 16.4 ± 1.0 km/h)	Selection	Unclear	Insufficient information about the sequence generation process and allocation to permit judgment of 'low risk' or 'high risk'.
						Performance	Unclear	Insufficient information to permit judgment of 'low risk' or 'high risk'.
						Detection	Unclear	Insufficient information to permit judgment of 'low risk' or 'high risk'.
						Attrition	Unclear	The study did not address this outcome.
						Reporting	Unclear	Insufficient information to permit judgment of 'low risk' or 'high risk'
						Other	Low	The study appears to be free of other sources of bias.

Table 1. *Cont.*

Author, Year	Method	Participants	Intervention	Outcomes	Results	Risk of Bias		
						Bias	Author's Judgment	Support for the Judgment
Kiviniemi_2010	Randomized controlled trial	Healthy men and women. Mean age of 34.57 years. *N* = 60. Men, *n* = 24; women, *n* = 36). ST: standard training (8 men + 8 women) + HRV-I: HRV-guided training for men and women (EG: 8 men + 8 women) + HRV-II: HRV-guided training tailored for women (12) + CG (8 men + 8 women). Location: Not specified Recruitment: advertisement local newspaper Inclusion criteria: healthy men and women Exclusion criteria: smoker, BMI ≥ 30 kg/m^2; regular physical exercise training more than twice a week for the last 3 months, competing athletes, mellitus, asthma, or cardiovascular disorders.	8 weeks of aerobic exercise sessions (40 min), vigorous-intensity level: HR between 85% of the HRpeak-5 bpm lower limit; moderate-intensity exercise was 70% of the HRpeak-5 bpm lower limit. HRV-I: if HRV increased or did not change, vigorous-intensity training on that day. If HRV decreased, moderate-intensity exercise or rest. HRV-II: vigorous-intensity exercise only when HRV had increased. ST group: two moderate-intensity and three vigorous-intensity exercises weekly. CG: no intervention No follow-up period. 7 withdrawals: ST (1 man + 1 woman) + HRV-I (7 men + 7 women); CG (7 men + 8 women) + HRV-II (10); 4 because of illness or injury and 3 because of insufficient compliance.	Primary: VO_{2max} (maximal bicycle ergometer test: direct measurement). Secondary: HR, RR interval with a heart rate monitor (SD1) while standing for 3 min, maximal load in the ergometer test.	VO_{2max}: significant intragroup improvements in ST (men subgroup) (pretest = 50 ± 7; post-test = 53 ± 7 mL/kg/min), ST (women subgroup) (pretest = 35 ± 5; post-test = 37 ± 4 mL/kg/min), HRV-I (men subgroup) (pretest = 50 ± 6; post-test = 54 ± 6 mL/kg/min), HRV-I (women subgroup) (pretest = 36 ± 4; post-test = 39 ± 3 mL/kg/min), and in HRV-II (women subgroup) (pretest = 37 ± 5; post-test = 40 ± 5 mL/kg/min). HR: RR interval: significant intragroup improvements in HRV-I (men subgroup) (pretests = 13.7 ± 6.7; post-test = 16.9 ± 8.7 ms). Maximal load: significant intragroup improvements in ST (men subgroup) (pretest = 275 ± 28 W; post-test = 293 ±35 W), ST (women subgroup) (pretest = 179 ± 32 W; post-test = 198 ± 35 W), HRV-I (men subgroup) (pretest = 270 ± 29W; post-test = 300 ± 25 W), HRV-I (women subgroup) (pretest = 174 ± 28 W; post-test = 189 ± 25 W), and in HRV-II (women subgroup) (pretest = 177 ± 26 W; post-test = 194 ± 23 W)	Selection	High	Allocation based on the results of a laboratory test or a series of tests.
						Performance	Unclear	Insufficient information to permit judgment of 'low risk' or 'high risk'.
						Detection	Unclear	The study did not address this outcome.
						Attrition	High	High rates of loss to follow-up.
						Reporting	Unclear	Insufficient information to permit judgment of 'low risk' or 'high risk'.
						Other	Low	The study appears to be free of other sources of bias.
Nuuttila_2017	Randomized controlled trial	Males, 19–37 years. *N* = 24. EG = 13 and CG = 11. Location: not specified. Recruitment: not specified. Inclusion criteria: recreationally endurance training. Exclusion criteria: not specified	11 weeks (3 weeks of control + 8 weeks of training). EG: 2–5 sessions/week; CG: 6 sessions/week; time depended on the training intensity. EG: 4 moderate-intensity endurance training sessions + 20 high-interval intensity training sessions. Training MICT and HIIT according to HRV. CG: 22 moderate-intensity endurance training sessions + 20 high-interval intensity training sessions + 4 high-intensity strength training sessions No follow-up periods. 9 withdrawals: illness (*n* = 1), injuries (*n* = 2), personal reasons (*n* = 3), lack of adherence (*n* = 3).	Primary: VO_{2max} (maximal treadmill test: direct measurement). Secondary: basal heart rate, maximal heart rate, lactate in the treadmill test, Vmax in the treadmill test, Vmax in the 10m test, time and lactate in the 3000 m test, rMSSD with a heart rate monitor + Firstbeat in a supine position for 3 min. Other: body weight, height in countermovement jump, strength in the concentric dynamic leg press, nocturnal heart rate variability, testosterone, and cortisol (blood samples), % of fat (InBody 720).	VO_{2max}: significant intragroup changes (EG = 3.1 ± 0.8 mL/kg/min; CG = 2.2 ± 0.6 mL/kg/min). Basal HR: significant intragroup decrease (EG = 4.4 ± 0.6 bpm; CG = 3.6 ± 0.1 bpm). Vmax in the treadmill test: significant intragroup improvements (EG = 0.9 ± 0.1km/h; CG = 0.5 ± 0.1 km/h). Vmax in 10 m: decreased significantly in CG from pre to mead test (0.08 ± 0.04 m/s). Time in the 3000 m test: significant intragroup decrease (EG = 35 ± 2 s; CG = 35 ± 6 s). Lactate in the 3000 m test: significant intragroup improvements (EG = 12 ± 18.4%) from mead-to post-test; CG = 16–0 ± 23.5%) from pre-to post-test. rMSSD: significant improvements in EG (13 ± 3 ms)	Selection	High	Allocation based on the results of a laboratory test or a series of tests.
						Performance	Unclear	Insufficient information to permit judgment of 'low risk' or 'high risk'.
						Detection	Unclear	The study did not address this outcome.
						Attrition	High	High rates of loss to follow-up.
						Reporting	Unclear	Insufficient information to permit judgment of 'low risk' or 'high risk'.
						Other	Low	The study appears to be free of other sources of bias.

Table 1. *Cont.*

Author, Year	Method	Participants	Intervention	Outcomes	Results	Risk of Bias: Bias	Risk of Bias: Author's Judgment	Risk of Bias: Support for the Judgment
Schmitt_2018	Randomized controlled trial	24 elite Nordic skiers (19 men, age 23.3 ± 3.6; 5 women, age 22.8 ± 4.1). *N* = 24; H-HRV, HRV-guided training normobaric hypoxic group (n = 9) + H, sleeping in normobaric hypoxia group (n = 9); N, normoxia group (*n* = 6). Location: French National Ski-Nordic Center. Recruitment: members of the cross-country ski and Nordic combined French. Inclusion criteria: elite Nordic skiers. Exclusion criteria: a history of altitude-related sickness and health risks that could compromise the subject's safety during training and/or hypoxic exposure.	Prior to pretest: 3 low-intensity training weeks (base training) with progressive training volume + 1-week recovery; Intervention: pretest + 15 days training (training load was organized into four training zones depending on the intensity and quantified as in Mujika et al. (1996), adapted to Nordic skiing (the threshold for training adjustment was chosen as 30% of the mean of the previous day) + postest1 + 1 week + postest2. Similar training content for each group. H-HRV group: sleeping normobaric in hypoxia (simulated altitude of 2700 m) with HRV-guided training; daily hypoxic dose was similar between H-HRV and H; Night SpO2 was similar between H-HRV and H, but lower than in N. H: traditional training sleeping in hypoxia (simulated altitude of 2700 m). N: traditional training sleeping in normoxia. Follow-up (post-test21 after 3 weeks of end postest1)	Primary: VO_{2max} (maximal treadmill test: direct measurement). Secondary: basal HR, peripheral oxygen saturation (SpO2), RR interval with a heart rate monitor (HF and LF) 5 min in a supine position and 5 min in standing, VO2 at the second ventilatory threshold. Others: duration of hypoxic exposure, HR, blood parameters (erythrocyte concentration, hemoglobin, hematocrit, ferritin), questionnaire of overtraining.	VO_{2max}: significant intragroup changes in H-HRV (3.8 ± 3.1%). Basal HR: significant intergroup differences (H-HRV = 55.38 ± 10.02 vs. H = 55.59 ± 4 bpm; H-HRV = 55.38 ± 10.02 vs. N = 47.11 ± 6.21 bpm). SpO2: significant intergroup differences (H-HRV = 90.4 ± 1.3 vs. N = 94.2 ± 0.8%). RR interval: no significant differences between intergroups (H-HRV = 9561.10 ± 9436.02 ms^2; H = 12,199.41 ± 1293.14 ms^2; N = 7441.2 ± 4954.16 ms^2). VO2 second VT: significant intragroup changes for H-HRV (6.7 ± 6.1%).	Selection	High	Allocation based on the results of a laboratory test or a series of tests.
						Performance	Unclear	Insufficient information to permit judgment of 'low risk' or 'high risk'.
						Detection	Unclear	The study did not address this outcome.
						Attrition	Low	No missing outcome data.
						Reporting	High	Not all of the study's prespecified primary outcomes have been reported.
						Other	Low	The study appears to be free of other sources of bias.
Vesterinen_2016	Randomized controlled trial	Recreational endurance runners (men = 20; women = 20) *N* = 40: EXP = 20 + TRAD = 20 Location: not specified. Recruitment: advertisement and social media Inclusion criteria: 2 years' regular endurance running training. Exclusion criteria: disease or regular medication for chronic or long-term diseases.	12 weeks (4 weeks of preparation + 8 weeks of training). The same volume as before the study for PREP and the same volume as for PREP for INT. EXP: training MICT and HIIT according to HRV. TRAD: 50% sessions at low-intensity and 50% sessions at moderate/high-intensity. Week periodization, 3:1. No follow-up periods. 9 withdrawals: sicknesses (*n* = 2), injuries (*n* = 2), lack of adherence (*n* = 5)	Primary: VO_{2max} (maximal treadmill test: direct measurement). Secondary: Speed in Lactate 1, speed in Lactate 2, mean speed in the 3000 m test, time in the 3000 m test, RR intervals (rMSSD) 4 min in a supine position.	VO_{2max}: significant intragroup improvements (EXP = 3.7 ± 4.6%, TRAD = 5.0 ± 5.2%). Speed in L1 significant intragroups improvement in EXP (2.8 ± 3.7%). Speed in L2 significant intragroups improvement in EXP (2.6 ± 3.3%) and TRAD (1.9 ± 2.2%). Time in the 3000 m test: significant intragroup improvements in EXP (–14.3 ± 14.1 s)	Selection	High	Allocation based on the results of a laboratory test or a series of tests.
						Performance	Unclear	Insufficient information to permit judgment of 'low risk' or 'high risk'.
						Detection	Unclear	The study did not address this outcome.
						Attrition	High	High rates of loss to follow-up.
						Reporting	High	Not all of the study's prespecified primary outcomes have been reported.
						Other	Low	The study appears to be free of other sources of bias.

4.1.3. Excluded Studies

As indicated in Figure 1, five studies were excluded from the qualitative analysis. Three studies were excluded because the VO_{2max} was not considered as an outcome [24,25,34], and two studies were excluded because they were not RCTs [35,36].

4.2. Risk of Bias in the Included Studies

The risk of bias in the included studies is summarized in Table 2. This assessment was made following the Cochrane Collaboration guidelines [30]. In addition, publication bias was assessed using a funnel plot (Figure 2). The Egger test provided statistical evidence of funnel plot symmetry, suggesting the absence of a significant publication bias (p = 0.101).

Table 2. Risk of bias in the included studies.

Study	Risk-of-Bias Domains						
	Selection	Performance	Detection	Attrition	Reporting	Other	Overall Risk of Bias
Javaloyes_2019	Unclear	High	Unclear	Low	Unclear	Low	Unclear
Kiviniemi_2007	Unclear	Unclear	Unclear	Unclear	Unclear	Low	Unclear
Kiviniemi_2010	Unclear	Unclear	Unclear	High	Unclear	Low	Unclear
Nuuttila_2017	High	Unclear	Unclear	High	Unclear	Low	Unclear
Schmitt_2018	High	Unclear	Unclear	Low	High	Low	Unclear
Vesterinen_2016	High	Unclear	Unclear	High	High	Low	Unclear

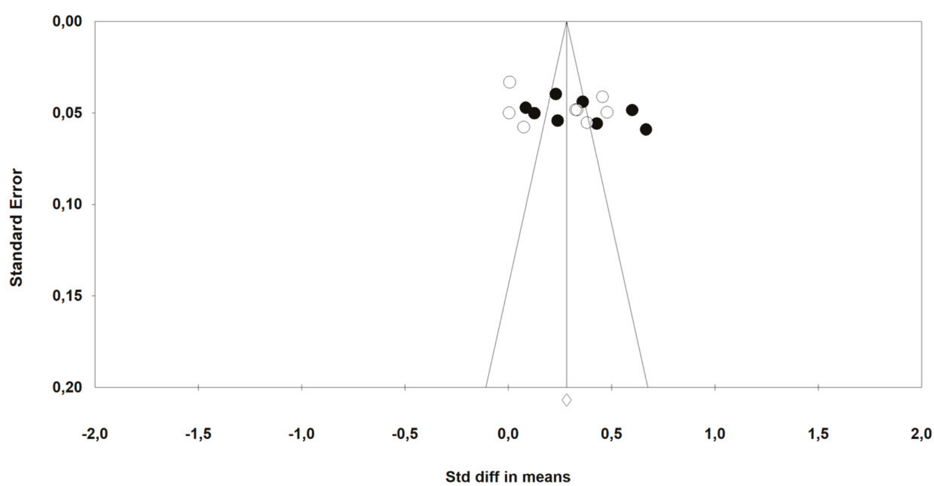


Figure 2. Funnel plot of standard error by standard differences in means (17 comparison; black circle, HRV-guided training; white circle, traditional training).

- Selection bias

In Javaloyes_2019, Kiviniemi_2007, and Kiviniemi_2010, neither the random component in the sequence generation nor the allocation concealment were described; therefore, the risk-of-bias selection was considered unclear. In Nuuttila_2017, Schmitt_2018, and Vesterinen_2016, the risk of bias was considered high because the randomization sequence was, in the first stage, based on the results of certain physical condition tests, sport discipline, age, or gender. Furthermore, in the second stage, the random component or the allocation concealment was not described.

- Performance and detection bias

The detection bias was considered unclear in all of the included studies because they did not address this outcome. The performance bias was also unclear in every study but Javaloyes_2019, which was considered high because only the participants were blinded, thus the blinding was incomplete.

- Attrition bias

In Javaloyes_2019 and Schmitt_2018, the attrition bias was considered low because there were no missing outcome data. On the other hand, Kiviniemi_2010, Nuuttila_2017, and Vesterinen_2016 presented high rates of follow-up loss for different reasons. These might be relevant in the ES observed. Moreover, no statistical procedure, such as intention-to-treat, was used to minimize this risk of bias. Therefore, they were considered as having a high risk of attrition bias. Finally, in Kiviniemi_2007, the attrition bias was unclear because this outcome was not addressed in the study.

- Reporting bias

The study protocols for the included studies were not available. Accordingly, Javaloyes_2019, Kiviniemi_2007, Kiviniemi_2010, and Nuuttila_2017 were considered as having an unclear reporting bias. For their part, Schmitt_2018 and Vesterinen_2016 did not report every outcome and were thus considered as having a high risk of reporting bias.

- Other biases

The included studies appear to be free from other sources of bias.

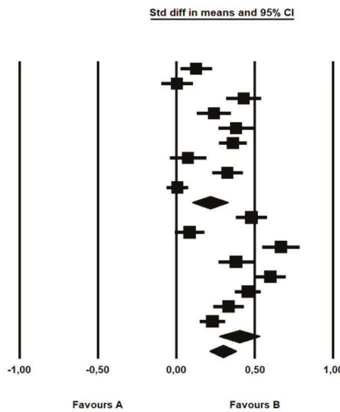
4.3. Synthesis of Results

The Kiviniemi_2010 and Schmitt_2017 studies were segmented for quantitative analysis according to their intervention groups. The comparisons were: Kiviniemi_2007 a, HRV (male subgroup, HRV-guided training) vs. standard training (ST); Kiviniemi_2010 a, HRV-1 (male subgroup, HRV-guided training) vs. standard training (ST); Kiviniemi_2010 c, HRV-I (female subgroup, HRV-guided training) vs. standard training (ST); Kiviniemi_2010 g, HRV-II (female subgroup, HRV-guided training tailored for women) vs. HRV-I (female subgroup, HRV-guided training); Kiviniemi_2010 f, HRV-II (female subgroup, HRV-guided training tailored for women) vs. standard training (ST); Schmitt_2017 a HRV (HRV-guided training) vs. N (traditional training and normoxia sleeping); Schmitt_2017 b HRV (HRV-guided training) vs. H (traditional training and hypoxia sleeping). Therefore, the total number of individual studies analyzed were 17 (k = 7 for the experimental group; k = 10 for the control group).

- Primary outcome measures

There were five studies (Kiviniemi_2007, Kiviniemi_2010, Nuuttila_2017, Schmitt_2017 and Vesterinen_2016) with significant intragroup VO_{2max} improvements in the HRV-guided training group (n = 95), while no significant changes were found in Javaloyes_2019 (n = 9). On the other hand, in three studies (Kiviniemi_2010, Nuuttila_2017, and Vesterinen_2016), there were also significant intragroup VO_{2max} improvements in the control group (n = 47). The overall risk of bias was considered high in every study but for Javaloyes_2019, which was considered unclear. A random-effects meta-analysis of the six studies revealed a statistically significant ($p < 0.0001$) treatment effect for VO_{2max} in the HRV-guided training intervention (ES = 0.402; 95% CI = 0.273, 0.531). Moreover, the other training intervention was also statistically beneficial ($p < 0.0001$) for VO_{2max} improvements in the control group (ES = 0.215; 95% CI = 0.101, 0.329). However, the ES for the VO_{2max} was significantly higher ($p < 0.0001$) in the HRV-guided training group. The heterogeneity observed in the meta-analysis was significant and high in the overall analysis ($p < 0.0001$; $I^2 = 94.24\%$) and for the experimental ($p < 0.0001$; $I^2 = 9.36\%$) and the control group ($p < 0.0001$; $I^2 = 92.26\%$) (Figure 3).

Group	Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
CG	Kiviniemi_2007 a	0,127	0,050	0,003	0,029	0,225	2,530	0,011	11,11
	Javaloyes_2019	0,004	0,050	0,003	-0,094	0,102	0,087	0,931	11,12
	Kiviniemi_2010 a	0,429	0,056	0,003	0,319	0,538	7,673	0,000	10,90
	Kiviniemi_2010 c	0,239	0,054	0,003	0,133	0,345	4,410	0,000	10,96
	Kiviniemi_2010 g	0,381	0,055	0,003	0,273	0,490	6,882	0,000	10,92
	Nuuttila_2017	0,360	0,044	0,002	0,274	0,447	8,190	0,000	11,33
	Schmitt_2018 a	0,075	0,058	0,003	-0,038	0,189	1,303	0,193	10,82
	Schmitt_2018 b	0,326	0,048	0,002	0,231	0,420	6,730	0,000	11,18
	Vesterinen_2016	0,007	0,033	0,001	-0,059	0,072	0,203	0,839	11,65
	CG	0,215	0,058	0,003	0,101	0,329	3,704	0,000	
HRV-G	Kiviniemi_2007 a	0,478	0,050	0,002	0,381	0,576	9,608	0,000	12,47
	Javaloyes_2019	0,085	0,047	0,002	-0,008	0,178	1,799	0,072	12,56
	Kiviniemi_2010 a	0,667	0,059	0,003	0,551	0,782	11,282	0,000	12,11
	Kiviniemi_2010 c	0,381	0,055	0,003	0,273	0,490	6,882	0,000	12,26
	Kiviniemi_2010 f	0,600	0,049	0,002	0,505	0,695	12,351	0,000	12,51
	Nuuttila_2017	0,456	0,041	0,002	0,375	0,536	11,058	0,000	12,76
	Schmitt_2018 a	0,333	0,048	0,002	0,238	0,428	6,877	0,000	12,52
	Vesterinen_2016	0,230	0,040	0,002	0,152	0,308	5,796	0,000	12,80
	HRV-G	0,402	0,066	0,004	0,273	0,531	6,126	0,000	
Overall		0,297	0,044	0,002	0,212	0,383	6,834	0,000	



CG
Heterogeneity: Tau² = 0.03; chi-square = 103.32, df = 8 (P < .00001); I² = 92.26%
Test for overall effect: Z = 11.95 (P < .00001)

HRV-G
Heterogeneity: Tau² = 0.03; chi-square = 105.41, df = 7 (P < .00001); I² = 93.36%
Test for overall effect: Z = 22.81 (P < .00001)

Overall
Heterogeneity: Tau² = 0.04; chi-square = 277.94, df = 16 (P < .00001); I² = 94.24%
Test for overall effect: Z = 24.38 (P < .00001)

Figure 3. Standard differences in means (SDM) between post- and premeasures for VO_{2max} in included studies, segmented by the control group (CG) and heart-rate-variability-guided training group (HRV-G). Squares represent the SDM for each trial; the diamond represents the pooled SDM across trials; weight determines how much each individual study contributes to the pooled estimate; 95%CI, confidence interval.

- Moderator analyses

Owing to the high heterogeneity observed in the meta-analysis, the potential moderating effect of the following was considered to be of interest: (a) the athletes' level (elite vs. amateur) and (b) the sex of the participants ('men vs. women' vs. 'men and women'). We had originally planned to take into account the intervention duration; however, it was not finally included as a subgroup owing to there being only one study that considered an intervention period of 15 days (Schmitt_2017) while the others conducted an eight-week intervention. The sample size was used for the metaregression. Following the moderating variables (Table 3), the athletes' level (elite vs. amateur) brought about statistically significant improvements ($p < 0.0001$) in both subgroups, while there were statistically significant differences between the subgroups ($p < 0.0001$) in favor of the nonprofessional subgroup (elite, ES = 0.17; amateur, ES = 0.36). According to the sex subgroups ('men vs. women' vs. 'men and women'), there were statistically significant improvements ($p < 0.0001$) in the three subgroups and statistically significant differences ($p < 0.0001$) between the three subgroups in favor of the women (men, ES = 0.33; women, ES = 0.40; men and women, ES = 0.19). The metaregression findings (Figure 4) revealed that the sample size of the studies was directly related to the ES magnitude (regression coefficient = −0.016; standard error = 0.003; lower limit = −0.023; upper Limit = −0.011; Z-value = −5.42; $p \leq 0.0001$).

Table 3. Subgroup analyses for measuring their impact on VO_{2max}.

Research Studies			Variable: VO_{2max}			
Group	**No Studies**	**References**	**SMD (95% CI)**	**I^2**	***p***	***p*-Difference**
Athlete level						
Elite	3	Javaloyes_2019; Schmitt_2018 a; Schmitt_2018 b	0.17 (0.03; 0.30)	89.63	<0.001	<0.001
Amateur	5	Kiviniemi_2010 a; Kiviniemi_2007 a; Kiviniemi_2010 c; Kiviniemi_2010 g; Nuuttila_2017; Vesterinen_2016	0.36 (0.24; 0.48)	94.66	<0.001	
Sex						
Women	3	Kiviniemi_2010 c; Kiviniemi_2010 f; Kiviniemi_2010 g	0.40 (0.25; 0.56)	88.36	<0.001	<0.001
Men	4	Javaloyes_2019; Kiviniemi_2007 a; Kiviniemi_2010 a; Nuuttila_2017	0.33 (0.17; 0.48)	94.98	<0.001	
Men and women	3	Schmitt_2017 a; Schmitt_2017 b; Vesterinen_2016	0.19 (0.06; 0.33)	92.10	0.006	

Note: SMD, standard mean difference; CI, confidence interval; VO_{2max}, maximal oxygen uptake; I^2 = I-squared.

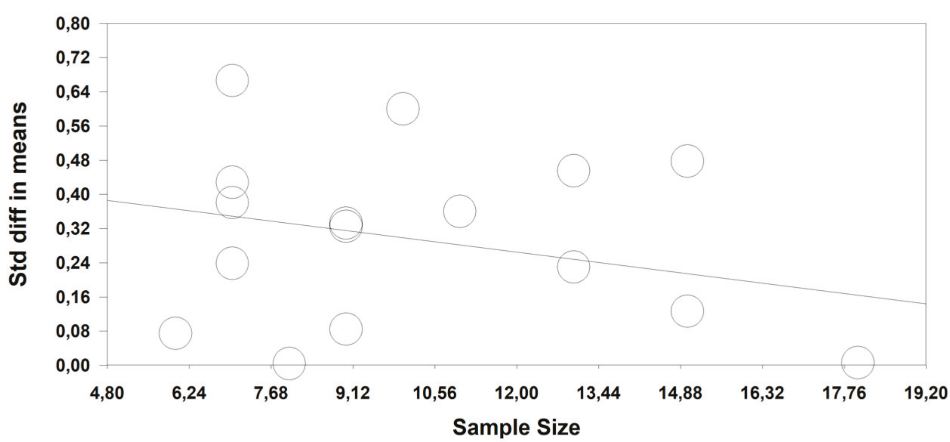


Figure 4. Metaregression of the number of participants (sample size) on standard differences in means (Std diff in means).

5. Discussion

5.1. Summary of Main Results

Six RCT studies evaluating the effects of an HRV-guided training intervention on endurance athletes were included in this review. The results of the meta-analyses provide some evidence that either HRV-guided training or traditional training may improve their performance in terms of VO_{2max} (HRV-G: ES = 0.402, $p < 0.0001$; CG: ES = 0.215, $p < 0.0001$). However, more favorable outcomes

($p < 0.0001$) for the experimental groups compared to the control groups were recorded across the studies. Moderators indicated larger effect sizes for interventions involving amateur endurance athletes (ES = 0.36, $p < 0.0001$) and women (ES = 0.40, $p < 0.0001$). On the other hand, the sample size of the studies was directly related to the ES magnitude ($p < 0.0001$).

5.2. Overall Completeness and Applicability of the Evidence

The total sample size of the studies meeting our original inclusion criteria was sufficiently large to warrant restricting the results to a meta-analysis of the RCTs. Data on the primary outcome (VO_{2max}) were measured directly using a gas exchange analysis system and a maximal test in each study. This is the most accurate way to obtain cardiorespiratory data. However, some studies implemented this test using a treadmill (Kiviniemi_2007, Nuuttila_2017, Schmitt_2017, and Vesterinen_2016) and others using a cycle ergometer (Javaloyes_2019 and Kiviniemi_2010). In the first case, training was based on running (Kiviniemi_2007, Nuuttila_2017, and Vesterinen_2016) and skiing (Schmitt_2017), which implies similar technical execution in the test. In the second case, the Javaloyes_2019 study was carried out on cyclists, whereas the Kiviniemi_2010 study sample was composed of runners. Statistical improvements regarding VO_{2max} were found in the Kiviniemi_2007 and Kiviniemi_2010 studies. However, the specificity of the test may be a source of variability and potential imprecision in the second study results. Following the training specificity principle [37], the body's physiological and metabolic responses and training adaptations are specific to the type of exercise and the muscle groups involved. Thus, the evaluation method should be as similar as possible to the training in order to obtain the most reliable results. This needs to be taken into account when interpreting the results.

Despite the intervention durations being quite homogeneous in the included studies (eight weeks for each study apart from Kiviniemi_2007 and Schmitt_2017), the total duration of the training process, preparation weeks included, endurance sport modality, and training intensities used for the control group (standard training) were different. There was also a marked heterogeneity in the sample of the included studies: elite (Javaloyes_2019 and Schmitt_2017) and amateur (Kiviniemi_2007, Kiviniemi_2010, Nuuttila_2017, and Vesterinen_2016) participants, or samples comprising only men (Javaloyes_2019, Kiviniemi_2007, Kiviniemi_2010, and Nuuttila_2017), women (Kiviniemi_2010), or men and women (Schmitt_2017 and Vesterinen_2016). A standardized training protocol should be recommended to ensure the optimal benefits regarding VO_{2max}.

5.3. Quality of the Evidence

The quality of the evidence from the included studies can be considered unclear. Despite each study being a randomized controlled trial, the sequence generation or the allocation concealment was considered skewed in half of them. The performance bias was high only in Javaloyes_20019, while the detection bias was unclear in all the studies because incomplete blinding was considered. Attrition was high in Kiviniemi_2010, Nuuttila_2017, and Vesterinen_2016 because of the high follow-up rates. In addition, the reporting bias was generally unclear due to the lack of a registered protocol.

5.4. Potential Biases in the Review Process

Although the systematic nature of the review process followed here decreases the potential for bias, the risk of bias in the review process remains. The greatest risk of bias present in this review was the study selection; specifically, the decision to limit the inclusion criteria to individual endurance sports, thus reducing the number of studies included and causing a potential limitation in the results.

- Agreements and disagreements with other studies or reviews

Based on the results from this systematic review with meta-analysis, and in response to Research Question 1, it is not surprising that the meta-analyzed results regarding improvements in athletes' VO_{2max} were associated with both training methodologies. According to Bartlett, O'Connor, Pitchford, Torres-Ronda, and Robertson [2] and Heyward [37], adequate prescribed training should maximize athletic performance when the specificity, overload, progression, initial level, individualization, diminishing return, and reversibility principles are followed. However, it was also found that the individual training adaptation according to the endurance athletes' daily HRV scores produced better VO_{2max} results than the standardized prescribed training, which answers Research Question 2. As pointed out by Vesterinen et al. [4,9], not every athlete improves their VO_{2max} after standardized group training. Similarly, Gallo, Cormack, Gabbett, Williams, and Lorenzen [38] reported that, in footballers, the internal load (perceived effort) of each athlete was different for a given external load; this definitely affects their individual performance during training and will be reflected in their individual performance improvements. Thus, daily individual HRV monitoring and training guidance balancing the sympathetic and parasympathetic autonomic nervous system leads to greater athletic performance in endurance athletes compared to standardized prescribed training. This is relevant if training optimization is the objective, supporting the idea that training should be prescribed appropriately to avoid overtraining and/or injury [38]. In the same vein, it is also interesting to point out that, according to studies such as Hulin, Gabbett, Lawson, Caputi, and Sampson [39] and Williams et al. [16], training individualization is also related to minimizing overuse and reducing the injury risk, which may be a correlative benefit in the pursuit of endurance athlete training optimization.

On the other hand, the meta-analyzed results show that VO_{2max} improvements were greater when the sample comprised amateur endurance athletes. This answers Research Question 3. According to the initial training level principle [37], individuals with a low initial level of physical fitness should achieve more significant relative increases than those of average or high levels. This is in accordance with the results of Sanchez-Sanchez et al. [40], where greater performance improvements were obtained in lower-level football players compared to the higher-level players, concluding that the lower the athlete's initial fitness level, the higher the available window of adaptability. Conversely, in the systematic review with meta-analysis by Hammami, Gabbett, Slimani, and Bouhlel [41], the athlete's level was not a determinant variable in terms of VO_{2max} enhancement since it improved if they were elite or amateur players. It should be noted that this review was conducted on football players and that randomized and nonrandomized controlled trials were included.

According to our meta-analyzed results, and in response to Research Question 4, there were higher effect sizes regarding VO_{2max} improvements when the sample was not mixed, especially in the case of women. There is controversy concerning the influence of sex on sport performance. Recent studies conducted on endurance athletes concluded that either sex was not a predictor variable of performance [42] or that performance between men and women was different in swimming, cycling, and running [43]. In the case of the present systematic review with meta-analyses, we consider that the initial level of the sample influenced the result, given that, in the Kiviniemi_2010 study, when female samples were analyzed, the participants were amateur level athletes. Thus, a higher relative performance increment is predictable based on the athletes' level.

6. Conclusions

6.1. Practical Implications

Training optimization to enhance performance in endurance athletes is a goal that is undergoing a constant process of improvement. Finding a procedure to objectively individualize the training would be ideal for achieving this goal. The meta-analyses results considered in this review suggest that HRV is a good indicator of physiological responses to training in endurance athletes. Consequently, using daily HRV scores for training individualization and prescription is an effective method for optimizing performance in endurance athletes. This is reflected in the improved VO_{2max} results when the training is guided by HRV, considering VO_{2max} as one of the main performance indicators. In addition, it should be taken into account that a lower initial athlete fitness level will be relevant in achieving greater VO_{2max} improvement. Although gender may be a variable that influences the performance gains, in our opinion, this result is primarily conditioned by the level of the athletes included in the analyzed studies. Therefore, we do not consider it to be a variable that clearly affects VO_{2max} improvements.

6.2. Research Implications

The results from this review suggest that, while there is evidence that HRV-guided training is effective at improving VO_{2max} in endurance athletes, there is still work to be done in terms of identifying the characteristics of the interventions that contribute to this effect and the characteristics of participants who are more likely to respond to such interventions. The most important point is that more research is required since only five studies were included in this review. Moreover, only two of the studies used samples composed of elite endurance athletes, which gave different results regarding VO_{2max} improvement. Consequently, the research should be extended to the professional field in order to clarify the effect of guiding training on VO_{2max}. This would also help to clarify whether the endurance sport modality is determinative of the VO_{2max} enhancement when following this training methodology.

Using daily HRV scores to control the training load and intensity over eight weeks is enough to improve VO_{2max} in endurance athletes. Nonetheless, the training protocol should be further standardized in terms of adjusting the number of preparation weeks or considering the measurement weeks within or around the training period, factors that determine the training duration. Moreover, the standardized training protocol used in the control groups varied between the studies, which considered low, moderate, or high training intensities, as well as different numbers of sessions per week and session durations. This might very well have influenced the VO_{2max} results. Therefore, it is necessary to reach a consensus regarding a standardized training protocol to use in future studies. In this line, it has been recently published a protocol [44] that could clarify the studies design. Similarly, although each study in this review used the most accurate method available to obtain the cardiorespiratory data, in the future, we should consider using a measuring instrument that allows us to implement the most specific sport technique in order to minimize result variability and imprecision.

Regarding the quality of the studies, authors should consider: improving the sequence generation or allocation concealment, the blinding of the participants, personnel, and outcome assessors, the rates of follow-up loss, using statistical procedures such as intention-to-treat to minimize attrition bias, and registering their protocols before starting the randomized controlled trial.

Lastly, to reinforce knowledge regarding performance optimization in endurance athletes, a good way to supplement the effect of HRV-guided training might be to register the risk of injuries associated with overuse using tools such as the Oslo Sports Trauma Research Center Overuse Injury Questionnaire, since this considers additional aspects affecting the execution of athletes' training.

Author Contributions: Research concept and study design, A.G.-G. and M.C.-P.; literature review, A.G.-G., M.C.-P., and A.G.-Q.; data collection, A.G.-G., M.C.-P., and A.G.-Q.; data analysis and interpretation, A.G.-G., M.C.-P., and A.G.-Q.; statistical analyses, A.G.-G. and M.C.-P.; writing of the manuscript, A.G.-G., M.C.-P., and D.P.; reviewing/editing the draft of the manuscript, M.C.-P. and D.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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International Journal of
Environmental Research and Public Health

MDPI

Article

Satisfaction, Enjoyment and Boredom with Physical Education as Mediator between Autonomy Support and Academic Performance in Physical Education

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Received: 27 September 2020; Accepted: 22 November 2020; Published: 30 November 2020

Abstract: The purpose of this study was to analyze the mediating effect of satisfaction/enjoyment and boredom between the perception of autonomy support and academic performance in physical education. The sample consisted of 374 girls (M_{age} = 13.99; SD = 0.30) and 374 boys (M_{age} = 14.02; SD = 0.33) from the state of Nuevo León, Mexico. The instruments used were the Questionnaire for Autonomy Support in Physical Education (CAA-EF), Sport Satisfaction Intrinsic in Physical Education (SSI-EF) and the physical education performance of the students. The instrument's validity tests were analyzed using confirmatory procedures. Descriptive, reliability, and validity analyses were carried out for each instrument, and the mediating effect was examined; a mediation analysis was performed using the PROCESS V.3.5 macro. The main results revealed that autonomy support is not a direct indicator of physical education performance, but rather that students must feel satisfied with physical education for there to exist a forecast for a positive physical education performance. Satisfaction with physical education was found to have a mediating effect between autonomy support and physical education performance. However, boredom did not have a mediating effect between autonomy support and the student's performance in physical education class.

Keywords: satisfaction; enjoyment; boredom; performance; autonomy support; physical education; secondary education; Mexico

1. Introduction

The poor academic performance of Mexican adolescents remains latent in the results from the Programme for International Student Assessment (PISA) 2018 Report. The academic level of secondary school students in Mexico is far inferior to the average for the countries of the Organization for Economic Cooperation and Development (OECD) (2018), having shown no improvement in this assessment since 2003. It is also important to mention that Mexicans scored very low as well in intrinsic satisfaction compared to the OECD average, a factor likely to affect the academic performance of adolescents [1].

Intrinsic satisfaction/enjoy may be examined according to the Theory of Subjective Well-Being [2]. This theory is composed of two dimensions: on the one hand, a person's general satisfaction with life;

and on the other hand, the affective dimension, understood as the result of immediate and continuous response to the conditions surrounding the students. In this way, satisfaction with school is interpreted as a cognitive-affective assessment of the general satisfaction experienced by the student [3]. It has been proven recently that levels of satisfaction with physical education (PE) forecast satisfaction with school, which is linked in turn to the academic performance of secondary school students [4,5]. But what strategies can the PE teacher apply to increase the levels of satisfaction with PE?

One way for the teacher to increase levels of satisfaction with PE is by supporting the autonomy of their students [6]. Autonomy support—together with competence and relationship—is one of the dimensions that form the Theory of Basic Psychological Needs [7], variables that have been studied extensively [8,9]. Autonomy refers to the level of independence and control that an individual has over their own choices; competence is defined as a person's capability to perform a certain task; and relationship means the connection that an individual has with other persons [10].

Autonomy, understood as a psychological disposition before a certain task, is vital in the educational environment, and especially in the field of PE, as it is linked to individual competences that are reinforced through teamwork. Instructions or orders for practical tasks from the teacher to the student encourage their autonomy and improve their concentration [11,12]. Moreover, as explained in Ntoumanis' research [13], the fulfillment of autonomy increases academic commitment, favors motivation, and prevents task abandonment and dropout rates in general [11]. According to Huescar, Fabra, and Moreno-Murcia [14], a broader autonomy support coming from the teacher, family, and peers is connected to the fulfillment of basic psychological needs, improved self-determined motivation, greater perceived control, a positive mindset and the intention to engage in physical activity.

Autonomy brings a perception of competence, capacity, and control over an individual's own decisions, which implies accepting the consequences of their behavior. Such perceptions of freedom and competence enable the student to face more complex challenges, generating more in-depth learning [15].

In this sense, fulfilling one's need for autonomy with regard to decisions and behaviors translates into an improved psychological well-being. In the educational field, nonetheless, autonomy is equally relevant for the learning process, given that the student's decisions come together with exercising various capabilities that teachers shall encourage [16]. The teacher's behavior in the classroom in terms of autonomy support is paramount in order to help achieve higher levels of motivation [17].

In this regard, an individual fulfilling their basic psychological needs (autonomy, competence, and relationship) will see their satisfaction with and commitment to ongoing activities increase [7], for example, their levels of physical activity during leisure time [18], which in turn translate into an improvement in their academic performance [19,20]. It is worth underscoring how important it is that students feel satisfied with PE class so that their levels of physical activity during their leisure time increase [21].

According to this, it is critical that students enjoy and feel satisfied with the PE class due to its connection to autonomy support [6], academic performance [5], and physical activity levels [21], which in turn relate to better academic performance [22]. On the contrary, when a student feels unsatisfied/boredom with PE class, their levels of physical activity decline [21], and their levels of school boredom [23] and potential school abandonment increase [24], among other variables.

For all that, the purpose of this study is to analyze the mediating effect of satisfaction/enjoyment and boredom between the perception of autonomy support and academic performance in PE.

2. Materials and Methods

2.1. Design and Type of Research

This study features a non-experimental, cross-sectional and correlational-causal design [25]. This research was carried out in accordance with the 1961 Declaration of Helsinki (Edinburgh revision, 2000). Approval was obtained from the Secretaría de Educación Pública of Mexico (identification number: 431/569/E) and The Universidad Autónoma de Baja California, Mexico.

2.2. Participants

Sample design was probabilistic by centers, stratified, multistage, and by proportional affixation, comprised of third-grade secondary school students from Nuevo León, Mexico. Participant schools were selected at random. The number of third-grade secondary school students in the state of Nuevo León was 13,396 girls and 13,831 boys. A representative sample was calculated according to sex for a finite population with a confidence level of 95% and a margin of error of +5%, consisting of 374 girls (M_{age} = 13.99; SD = 0.30) and 374 boys (M_{age} = 14.02; SD = 0.33).

2.3. Instruments

The questionnaire used was comprised of the following scales. To measure autonomy support from the PE teachers, we used the CAA-EF validated for the Mexican context by Maldonado, Pacheco and Zamarripa [26]. This questionnaire was adapted from the Learning Climate Questionnaire by Williams and Deci (1996), based in turn on the Health-Care Climate Questionnaire [27], which contains 15 items to measure the professor's support for autonomy through one dimension: autonomy support. The guideline is to grade according to the items; answers are given on a seven-point scale of polytomous items ranging from 1 (strongly disagree) to 7 (strongly agree). In previous studies with a Mexican sample the CAA-EF had acceptable fit indexes (NNFI = 0.99, CFI = 0.99 and RMSEA = 0.06) and the internal consistency (α = 0.92) was acceptable [26].

To measure intrinsic satisfaction (enjoyment and boredom) in PE, we used the Sport Satisfaction Intrinsic in Physical Education (SSI-EF) instrument adapted to the Mexican context by Baños et al. [4]. The instrument is composed of eight items; five of them measure the level of satisfaction/enjoyment with academic activities for each subject, while the remaining three measure boredom. The scale is preceded by the phrase: "Tell us how much you agree or disagree with physical education". Answers were given using a Likert scale ranging from 1 (completely disagree) to 5 (strongly agree). In previous studies with a Mexican sample the SSI-EF had acceptable fit indexes (NNFI = 0.96, CFI = 0.97 and RMSEA = 0.04) and the alpha values found were 0.78 for the satisfaction/enjoyment subscale and 0.65 for the boredom subscale [4].

Academic performance in PE. We asked teachers to provide their latest test score records in order to analyze the students' grades. This procedure guarantees a better reliability than the one used by Baños et al. [5], where grades were requested from the students themselves. These were recorded in a scale of polytomous items ranging from 1 to 10.

2.4. Procedure

In order to carry out this study, a research project called "Programme for International Student Assessment: relationship between school performance in secondary school students and psychological, family, and physical activity variables" was first presented to, and later approved and subsidized by the Secretaría de Educación Pública. Then, authorization was requested from school principals, providing the parents/guardians involved with information for consent detailing the purpose and intentionality of the study. Following their approval, the data collection procedure began by informing the participants of the study's purpose, that participation was anonymous and voluntary, and that their answers were to remain confidential, reminding them that there were no right or wrong answers, and asking them to answer with complete honesty. All questionnaires were filled inside the classroom in the presence of the lead researcher in case of doubts during the procedure, which lasted 15–20 minutes. The data was collected in September 2019.

2.5. Statistical Analysis

Initially, an analysis for multivariate normality was performed. To that end, we conducted a normality test based on the PRELIS relative multivariate kurtosis test (RMK) using the LISREL 8.80 software. Once normality was determined, or not, a confirmatory factorial analysis (CFA) was carried out to assess the proper adequacy of these instruments in regard to the samples used in this research. Several reliability and validity indices were calculated for each instrument, including Cronbach's alpha, composite reliability, and average variance extracted (AVE). Then, analyses were carried out to determine the correlation among the instruments used. Subsequently, several structural equation models were created in order to meet the purpose of this study. Statistical Package for the Social Sciences SPSS v.22 (IBM, Armonk, NY, USA) and the Linear Structural Relations (LISREL) V.8.80 software (Scientific Software International, Inc., Lincolnwood, IL, USA) were used for these calculations.

In addition, a mediation analysis (model 4) was carried out in the PROCESS V.3.5 macro (www.processmacro.org) [28] for the SPSS Statistics software V.21 (IBM, Armonk, NY, USA) to determine whether the correlation between autonomy support and PE grades was mediated by enjoyment and boredom during class. Confidence intervals (95%) were generated using a bootstrap of 10,000 samples to determine the outcomes of the model. Likewise, we calculated the indirect effects of autonomy support (X) and PE grades (Y) through enjoyment (M1) and boredom (M2).

3. Results

3.1. Data Normality Analysis

Table 1 shows the normality data of the measurement instruments, where data finally show a non-normal behavior. The RMK values were 1.380 for CAAEF and 1.805 for SSI-EF.

Table 1. Values of multivariate normality test.

Instrument	Multivariant Normalized Kurtosis	Mardia-Based Kappa	Higher Limit	Lower Limit
CAA-EF	58.8716	0.38	1.018	0.983
SSI-EF	69.8543	0.805	1.032	0.968

3.2. Confirmatory Factor Analysis

First, CFA were performed for each instrument to confirm their validity and reliability in regard to the sample expected to be used in this research. Results proved (Table 2) to be acceptable within the threshold established in χ^2/df [29,30], in the goodness of fit index (GFI) [31], comparative fit index (CFI), normed fit index (NFI), non- normed fit index (NNFI) [32], and in the root mean square error of approximation (RMSEA) [33,34].

Table 2. Adjustment indices of each model.

Instrument	χ^2	df	χ^2/df	p	GFI	CFI	NFI	NNFI	RMSEA
CAA-EF	303.66	90	3.37	0.000	0.99	0.98	0.97	0.98	0.056
SSI-EF	34.30	19	1.80	0.016	0.99	0.97	0.94	0.96	0.040

Note. GFI = goodness of fit index, CFI = comparative fit index, NFI = normed fit index, NNFI = non-normed fit index, RMSEA = root mean square error of approximation.

3.3. Reliability and Validity Analysis

Table 3 shows an analysis for each model with the values for Cronbach's alpha, composite reliability, and average variance extracted (AVE). As can be seen, all reliability, AVE and almost all α indices exceed the acceptable threshold according to Dunn, Baguley, and Brunsden [35] and Hair, Black, Babin, and Anderson [36]. However, because of the limited number of items per factor (as is the case with the boredom dimensions), $\alpha \leq 0.70$ values may be deemed acceptable [37]. Moreover, it must be kept in mind that composite reliability is preferred over Cronbach's alpha in ordinal data scales, as the former does not depend on the number of attributes associated to each concept [38].

Table 3. Scale of reliability and composite validity.

Variable	*M*	*SD*	95% CI		IQR	CR	AVE	α
Autonomy Support	4.07	1.53	3.96	4.18	2.27	0.93	0.50	0.95
Satisfaction/Enjoyment	3.68	1.01	3.60	3.74	1.50	0.89	0.63	0.84
Boredom	2.48	1.13	2.40	2.57	1.60	0.67	0.55	0.68

Note. M = mean; SD =standard deviation; 95% CI = confidence interval; IQR = interquartile range; CR = composite reliability; AVE = average variance extracted.

3.4. Correlation Analysis

Table 4 shows how perceived autonomy support correlates positively and significantly with satisfaction/enjoyment (0.526 **) and PE score (0.122 **), and negatively with boredom in PE (−0.087 *). satisfaction/enjoyment with PE correlated positively with PE score (0.170 **) and negatively with boredom (−0.259 **). Boredom in PE was negatively correlated with PE score (−0.085 *).

Table 4. Correlation analysis.

Variable	1	2	3
1. Autonomy Support			
2. Satisfaction/Enjoyment	0.526 **		
3. Boredom	−0.087 *	−0.259 **	
4. PE score	0.122 **	0.170 **	−0.085 *

Note. ** $p < 0.01$, * $p < 0.05$.

3.5. Mediating Effect

The proposed model calculated the effect of mediation from satisfaction/enjoyment (M1) and boredom (M2) on the interaction between autonomy support (X) and the grades obtained in PE class (Y).

Results revealed that autonomy support was positively and significantly correlated with satisfaction/enjoyment in PE class ($a_1 = 0.351$; $p < 0.001$), however, this was not the case with boredom ($a_2 = 0.042$; $p = 0.113$). Likewise, enjoyment and PE grades were positively and significantly correlated ($b_1 = 0.166$; $p < 0.001$), contrary to the correlation between boredom and PE grades, which was not significant ($b_2 = 0.041$; $p = 0.212$) (see Table 5 and Figure 1).

Table 5. Regression coefficients, standard errors, and model summary information for the mediational effects of satisfaction/enjoyment and boredom in the relationship between autonomy support and PE score.

Antecedent	M_1 (Satisfaction/Enjoyment)			M_2 (Boredom)			Y (PE Score)			
	Coeff.	SE	p	Coeff.	SE	p	Coeff.	SE	p	IE
X (Aut. Sup.)	0.351	0.024	<0.001	0.042	0.026	0.113	0.022	0.027	0.432	
M_1 (Satisfaction/Enjoyment)							0.166	0.043	<0.001	0.058 *
M_2 (Boredom)							0.041	0.033	0.212	0.002
Constant	2.246	0.086	<0.001	3.353	0.115	<0.001	8.223	0.165	<0.001	
	$R^2 = 0.284$			$R^2 = 0.0003$			$R^2 = 0.041$			
	$F_{(1, 751)} = 297.548$, $p < 0.001$			$F_{(1, 751)} = 2.523$, $p = 0.113$			$F_{(3, 749)} = 10.676$, $p < 0.001$			

Note. Aut. Sup = autonomy support; PE = physical education; Coeff. = coefficient; IE = indirect effect. * = indirect effect significant (confidence intervals do not include zero).

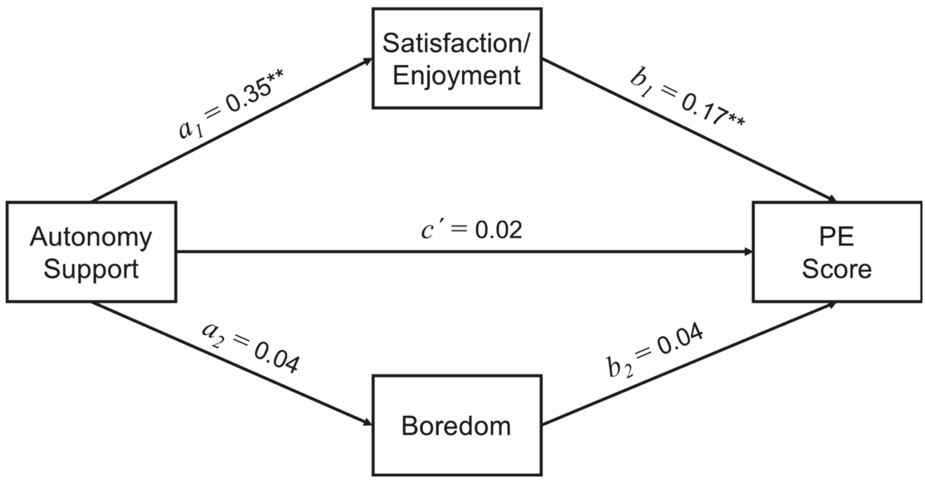

Figure 1. Statistical diagram of the satisfaction/enjoyment and boredom as mediators between autonomy support with PE score. ** $p < 0.001$.

As shown in Table 5, the interaction between autonomy support and PE grades was not mediated by boredom (IE = 0.002; IC = −0.0014; 0.0064). However, enjoyment had an indirect, positive and significant effect (IE = 0.058; IC = 0.0270; 0.0917) on the interaction between autonomy support and PE grades.

4. Discussion

The purpose of this study was to analyze the mediating effect of satisfaction/enjoyment and boredom between the perception of autonomy support and academic performance in PE. The psychometric properties of CAA-EF and SSI-EF supported the reliability and validity of both scales. Similar results were achieved by other researchers, both in the Mexican context for CAE-EF [26] and SSI-EF [24], as well as in their original version for CAA-EF [39] and SSI-EF [40].

In terms of the correlation analysis, the results obtained confirm a positive correlation among autonomy support, satisfaction/enjoyment, and PE score, although the correlation scores obtained are low. On the contrary, boredom during PE class correlates negatively with autonomy support and PE score. In this sense, other studies found a correlation between autonomy support from the PE teacher and intrinsic motivation, and the sense of competence and autonomy from the students [17], positive correlations between students and satisfaction with PE class [8,41,42]. Moreover, it has been demonstrated that a student's satisfaction with PE class forecasts a positive PE score [4,5]. Therefore, autonomy support may increase satisfaction with PE and keep the student from boredom, also increasing motor engagement in the classroom and adherence to extracurricular sport activities [6].

Said positive correlation between autonomy support, satisfaction/enjoyment, and PE performance might be a result of responsibility being transferred from the teacher to the students, thus allowing them to make their own decisions while acknowledging personal effort and self-improvement, as well as the spectrum of activities to perform during PE class [8,41,43,44]. Other studies have revealed that when teachers choose to exercise autonomy support over strategies for control, the students are more likely to participate in proposed tasks, exhibit a greater commitment to their activities and perceived competence, and feel more satisfied with their lives [45].

The main focus of this study was to analyze the mediating role of satisfaction/enjoyment and boredom with PE in the correlation between the perception that students have about the PE teacher's support for autonomy and the academic performance achieved in the subject. In terms of the mediating effects over satisfaction/enjoyment and boredom with PE, satisfaction/enjoyment with the PE subject had a mediating effect between the academic performance achieved in the class and the teachers' support for autonomy. However, boredom with PE had no significant results on the mediating effect between autonomy support and academic performance. In this regard, Trigueros et al. [46] found that satisfaction with PE had a mediating effect between autonomy support in PE and the fulfillment/unfulfillment of basic psychological needs during physical activities. The results of this study make an important contribution to scientific literature. In order to see the student's academic performance increase in PE, the teacher should adopt not only an autonomy-supportive style, but also strategies to make the students enjoy and feel satisfied with PE class [47]. However, several studies have shown that levels of satisfaction/fun in PE class are lower in Mexican adolescents compared to students from other countries [48]. For this reason, it is important that teachers create fun and novel sessions, moving away from monotonous and boring classes [23,49,50].

It is worth mentioning that several researchers have demonstrated that students who engage in moderate and vigorous physical activity achieve better academic performance in mathematics and reading comprehension [19,22,51]. Nonetheless, although other studies have not found any significant correlations among these variables, physical activity levels did not negatively affect academic performance [52,53]. An explanation for this discrepancy in the scientific literature might lie on the scarcity of studies analyzing the mediating effect of autonomy support and satisfaction with PE between levels of physical activity and academic performance. Therefore, it would be interesting to see future researchers elaborate further on this field.

5. Limitations

This study faced some limitations which must be kept in mind, among which is the fact that only one dimension from the theory of basic psychological needs was considered (autonomy). For future research, it is recommended to analyze the other dimensions pegged to this theory as well (sense of competence and relationship with peers). However, in spite of these limitations, some strengths of this research shall be highlighted. The sample selection was probabilistic and random by centers, stratified, multistage, and by proportional affixation. Therefore, the study can be generalized for the state of Nuevo León, Mexico. In addition, this research topic may help create solutions for the key issues faced by teachers every day.

6. Conclusions

As a conclusion, the results of this study have shown that autonomy support does not directly predict PE performance, but rather that it is necessary that students feel satisfied with PE for there to be a positive forecast of the student's academic performance. In this way, satisfaction with PE has a mediating effect between autonomy support and academic performance. However, boredom with PE did not have a mediating effect between autonomy support and the student's academic performance.

Author Contributions: Conceptualization, R.B., and J.Z.; methodology, R.B., and J.F.; formal analysis, R.B., and J.Z.; investigation, R.B., L.C. and M.d.M.O.-C.; resources, R.B.; data curation, J.F.; Supervision, J.Z.; writing—original draft preparation, L.C., J.F. and M.d.M.O.-C.; writing—review and editing, R.B., and J.Z.; project administration, R.B.; funding acquisition, R.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Secretaría de Educación Pública of Mexico, grant number 431/569/E".

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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ISBN 978-3-0365-0245-8