applied sciences

MDPI

Article

Associations of Physical Fitness with Cognitive Performance in Children Aged 7–12 Years: A Cross-Sectional Study

Rafael Cortés-Rojas [1], María Isabel Castellano-Ruiz [2], Alberto Baeza-Medina [2], Francisco Javier Gil-Espinosa [3], Francisco Álvarez-Salvago [4,*] and José Daniel Jiménez-García [1]

[1] Department of Health Sciences, Faculty of Health Sciences, University of Jaén, 23071 Jaén, Spain; rafacortesrojas@gmail.com (R.C.-R.); josedanieljimenezgarcia@gmail.com (J.D.J.-G.)
[2] Faculty of Sport Sciences, EADE-University of Wales Trinity Saint David, 29018 Málaga, Spain; mariacastellanoedf21@alumlos.eade.es (M.I.C.-R.); a.baeza14@gmail.com (A.B.-M.)
[3] Department of Languages, Arts and Sports, Faculty of Education, University of Málaga, 29009 Málaga, Spain; javiergil@uma.es
[4] Department of Physiotherapy, Faculty of Health Sciences, European University of Valencia, 46010 Valencia, Spain
* Correspondence: salvagofran@gmail.com; Tel.: +34-630-734-363

Abstract: (1) Background: The objective of the present study was to analyze the association of physical fitness, specifically lower limb strength, abdominal strength, vertical jump, and grip strength, with cognitive performance, specifically focusing on selective attention and memory in children aged 7 to 12 years. (2) Methods: Two hundred twenty-seven students participated in this study. Pearson correlation was used to analyze potential relationships between the independent variables and dependent variables. (3) Results: In relation to physical fitness, a higher number of abdominal repetitions performed in 30 s showed a significant and positive association with a higher number of correct responses assessed by the Stroop Test. Furthermore, at a functional level, higher grip strength correlated with a greater number of correct responses and a higher average correct response time in the Stroop Test. Additionally, grip strength showed a significant and positive correlation with the number of words recalled assessed by the word recall test. Our key findings showed a significant association of grip strength with the categories of cognitive status, selective attention, and memory. (4) Conclusions: This study reveals that physical fitness levels, especially grip strength and abdominal strength, correlate with selective attention capacity in primary school students.

Keywords: academic performance; cognitive status; memory; physical fitness; selective attention; Stroop Test; students; Word List Recall Test

Citation: Cortés-Rojas, R.; Castellano-Ruiz, M.I.; Baeza-Medina, A.; Gil-Espinosa, F.J.; Álvarez-Salvago, F.; Jiménez-García, J.D. Associations of Physical Fitness with Cognitive Performance in Children Aged 7–12 Years: A Cross-Sectional Study. *Appl. Sci.* **2024**, *14*, 4965. https://doi.org/10.3390/app14124965

Academic Editors: Marios Hadjicharalambous and Nikolaos Zaras

Received: 25 April 2024
Revised: 4 June 2024
Accepted: 5 June 2024
Published: 7 June 2024

1. Introduction

In recent years, gathering information about cognitive status in adolescents has emerged as a significant area of study given its profound impact on essential domains such as physical health, mental health, academic performance, quality of life, and social development [1]. Concerningly, data from recent studies show that at least 20% of adolescents experience a decline in cognitive performance [2]. It is important to know the different stages in which a subject can be found, since in each of them, different characteristics and abilities are shown. According to the World Health Organization (WHO), individuals between six and twelve years old are in a stage called childhood. Likewise, the last years of this stage are known as early adolescence according to Allen and Waterman 2019 [3]. The results of our research in children show similarities with the results found in adolescents; thus, we can talk about them as a group even if there are differences in ages.

When addressing cognitive breadth in adolescents, selective attention represents a highly important research area given its fundamental role in young individuals' ability

to process and retain relevant information in increasingly complex and stimulating environments [4]. Within the spectrum of cognitive skills, selective attention has been the subject of considerable interest during adolescence [5]. This phenomenon manifests itself as the cognitive tool that facilitates the interpretation and selection of relevant information, considering the stimulus received. Therefore, this function in the context of educational activities regulates all the processes and mechanisms through which the organism manages teaching and learning actions, responding only to those demands of the environment that are useful or significant for children [6]. This fundamental cognitive ability is implicated in a wide range of activities, influencing the likelihood of success in academic, athletic, or social behaviors, thus acquiring potential value for the development of educational strategies and interventions that promote more effective learning [7,8].

Furthermore, memory not only facilitates learning and the retention of academic information, but also influences how the student relates new information to previously memorized information, playing a crucial role in cognitive and academic development [9]. It is for this reason that short-term memory in adolescents has highly practical and important implications for improving the well-being and academic success of this population [10].

Interestingly, the relationship between physical fitness and these cognitive abilities, selective attention, and memory suggests that adolescents with higher fitness levels also demonstrate better performance on tests assessing cognitive status [11]. Researchers such as Hillman et al. [12] have demonstrated that physical fitness is a key component in understanding the connections between physical fitness and cognitive performance.

To date, research on the relationships between children's and adolescents' physical fitness or sports habits and various aspects of cognitive functioning has primarily focused on assessing aerobic endurance [13]. Consistent with this focus, physical fitness, especially cardiorespiratory fitness, which is recognized as a crucial indicator of health in children and adolescents [14], has also been positively linked to cognitive functions, including academic achievements [15,16]. For example, Coe, Peterson, Blair, Shutten, and Peddie [17] found that sixth- and ninth-grade students with high physical fitness achieved significantly higher scores on mathematics and social studies tests compared to those with lower physical fitness. Once again, there are studies that discuss children and adolescents as a whole, such as a study carried out by Páez-Maldonado in 2020 [18] in ten- and twelve-year-old children, which showed significant relationships between physical fitness and cognitive functioning and academic performance, with cardiorespiratory fitness being the best predictor for cognitive functioning and academic performance, as mentioned above. Moreover, recent research suggests that not only cardiorespiratory fitness, but also muscular strength, may play a crucial role in these outcomes [19,20].

Therefore, the objective of the present study was to analyze the association of physical fitness, specifically lower limb strength, abdominal strength, vertical jump, and grip strength, with cognitive performance, specifically focusing on selective attention and memory in children aged 7 to 12 years.

2. Materials and Methods

2.1. Participants

This current descriptive study was conducted in December 2023 and January 2024 and involved students from León XIII School in Andalusia. A total of 227 students participated, comprising 53% boys and 47% girls. The inclusion criteria required participants to be school-aged children (7–12 years old) without functional problems, while the exclusion criteria included children with difficulties on physical and psychological tests (Figure 1). Informed consent for participation was obtained from parents, and all assessments were carried out at the school itself. The variables measured included selective attention, memory, lower limb strength, abdominal strength, upper limb strength, and vertical jump. Approval was granted by the Ethics Committee of the University of Wales (EADE, Spain) (001/PE/TS/2023), and the study adhered to the principles of the Declaration of Helsinki, good clinical practices, and relevant laws and regulations. Based on an estimated incidence

of 30% in the target group, the study's sample size was obtained using a formula for estimating the proportion where the assumed rate was 0.3, with $\alpha = 0.05$ and a precision of ± 0.06. A 25% safety margin was added to account for registration failures, drop-outs, or individuals who did not want to participate; therefore, a required sample size of 215 subjects was calculated.

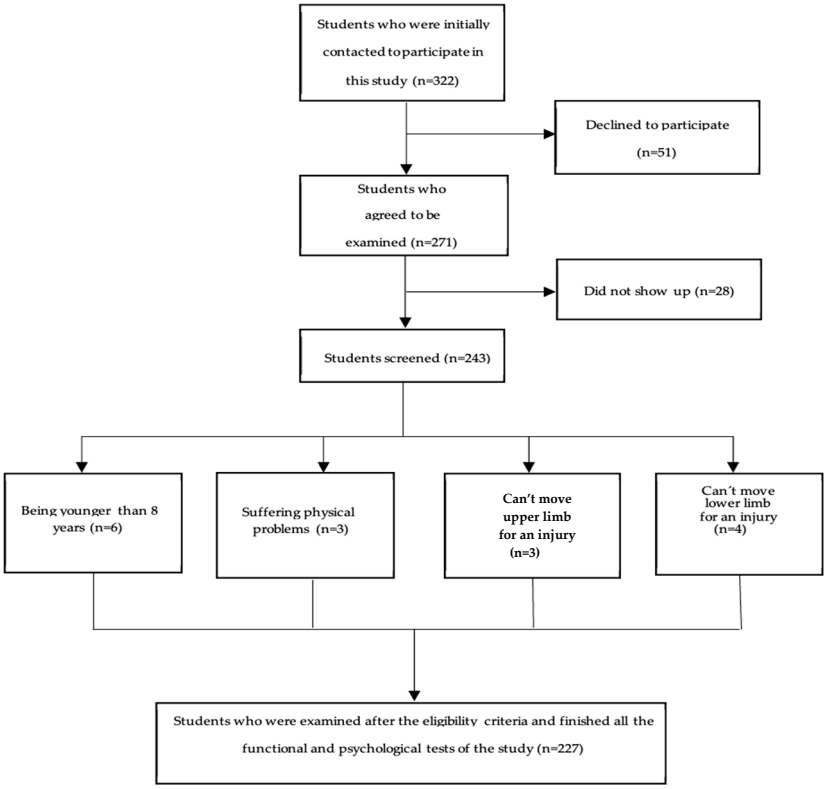

Figure 1. Flow chart of participants.

2.2. Sociodemographic and Anthropometric Information

Prior to conducting the various functional and cognitive tests, a sociodemographic questionnaire was administered to each participant, including information such as age and date of birth. Weight was assessed using a scale and height with a measuring tape. Body mass index (BMI) was calculated by dividing the participant's weight in kilograms by their height squared in meters. Furthermore, all students were asked whether they practiced sports (more than 150 min/week) outside of school.

2.3. Selective Attention

To measure selective attention, the Stroop Test, also referred to as the Strop Color Word Test or Stroop Effect Test, was utilized. It serves as a neuropsychological assessment aimed at gauging the inhibition of cognitive interference, frontal lobe functionality, selective attention, and cognitive flexibility. Essentially, it evaluates our ability to intentionally focus on a single piece of information (color) while disregarding other information which is typically processed automatically (word reading) [21].

During the test, participants were presented with three lists and instructed to read them aloud as quickly as possible. One list comprised color names printed in black ink, another consisted of colored squares where participants were required to name the color, and the third included words printed in colors different from their semantic meanings. Scores were determined by the number of correct responses generated within a 45-s timeframe [22]. A shorter amount of time taken to give the correct responses yielded a better score.

2.4. Memory

Memory was assessed using the Word List Recall Test, which involved a memory trial with a list of 10 words. The words were presented via a screen with a 1-s interval between words. Following 60 s of conversation with the participants, they were asked to write down the maximum number of words remembered. All words were written down, including repetitions (correct words mentioned multiple times) and intrusions (words not on the target list). The test score was the number of correctly recalled words, regardless of order [23].

2.5. Lower Limb Strength

To measure lower limb strength, the horizontal jump test with both feet together was employed. This test is commonly used to assess the explosive muscle strength of the lower body in youth [24]. It involves performing a jump with both feet together over a line. The participant must jump the maximum horizontal distance possible without excessively separating the feet. They have three attempts to do so. Each jump is measured (in cm) with a meter from the takeoff line to the point of the nearest heel. For the primary analysis, we used the greatest distance achieved among these three attempts. Execution: Participants started behind a line, with their feet at the same height and slightly apart. The jump was not valid if the line was crossed with the feet before leaving the ground.

2.6. Abdominal Strength

To measure abdominal muscle strength, the sit-up test was utilized. This test involved performing as many sit-ups as possible within 30 s. Upon completion of the test, the number of sit-ups performed was recorded. Execution: The participant lay supine on a mat, hands on the shoulders, and knees bent at a 90-degree angle. The monitor held onto the participant's ankles. In each repetition, at the end of the concentric phase, the elbows were required to touch the knee on the same side, and at the end of the eccentric phase, the scapulae were required to return to touch the mat. Participants were encouraged to breathe easily to avoid performing the Valsalva maneuver [25].

2.7. Hand Grip Strength

Hand grip strength was assessed using a digital dynamometer (T.K.K. 5101 Grip-D; Takey, Tokyo, Japan), with the results recorded in kilograms. The dynamometer's precision was reported to be 0.1 kg. During measurement, participants were directed to uphold the conventional bipedal stance throughout the examination, with their arm fully extended and avoiding contact between the dynamometer and any body part except the hand being assessed. Each participant completed the test twice (alternating between hands), employing varied grip spans in a randomized sequence, with a 1 min rest interval between measurements [26].

2.8. Vertical Jump

To measure vertical jump height, the countermovement jump test (CJT) was conducted. The test entailed participants standing in a bipedal position with feet parallel and separated approximately at hip width, ensuring full contact with the ground. The trunk remained upright and the hands were placed on the waist until the completion of the test.

After maintaining the initial position for 2–3 s, participants descended to a position resembling a half squat, with knee flexion angle ranging between 90° and 120°. Without pause, participants performed a knee extension to achieve the highest possible vertical jump while maintaining trunk verticality. They were instructed to fix their gaze on the nearby horizon. Upon landing, their knees were required to be fully extended and their ankles to be in plantar flexion.

For this test, the jump should be as vertical as possible, as any deviation from the center of gravity's trajectory angle could lead to an increase in flight time; for the same reason, participants were also required to have their knee and ankle joints as extended as

possible upon landing. The OptoGait analysis system (Microgate Italy, Bolzano, Italy), an opto-electrical detection system, was utilized for jump analysis. We selected the best jump from the two attempts made by each participant [27].

2.9. Data Analysis

The data were analyzed using the statistical software package SPSS v26.0 for Windows (SPSS Inc., Chicago, IL, USA). The level of statistical significance was set at $p < 0.05$. The Kolmogorov–Smirnov test was used to examine the normality of the variables. Continuous variables were described using means and standard deviations, and categorical variables were described using percentages and frequencies. Pearson correlation was used to analyze potential relationships between the independent variables and dependent variables. Additionally, all statistical analyses were adjusted for confounding variables, including sex, age, BMI, and physical activity practice. Furthermore, a confidence level of 95% ($p < 0.05$) was used to assess the association between the independent variables (lower limb strength, abdominal strength, vertical jump, and grip strength) and the dependent variables (Stroop correct responses, Stroop fastest correct response, Stroop average response time, Stroop average correct response time, and word recall). Finally, the effect size of the differences between sexes in the descriptive data of participants was interpreted using Cohen's d statistic. An effect size of <0.2 reflects a negligible difference; ≥0.2 but ≤0.5 a small difference; ≥0.5 but ≤0.8 a moderate difference; and ≥0.8 a large difference.

3. Results

Table 1 presents the descriptive data of the participants. A total of 227 students (age: 9.92 ± 1.33 years) participated in the present study. The participant sample was nearly homogeneous, with 52.42% boys and 47.68% girls. The sample was evenly distributed across the five grade levels, with each grade representing no more than 25% of the total sample. The mean BMI was 18.44 ± 3.31 kg/m^2, and over 60% of the participants engaged in physical activity outside of school.

Table 1. Descriptive socio-demographics, anthropological measures, and physical/cognitive test results.

Characteristics		Total (n = 227)		Boys (n = 119)		Girls (n = 108)		Cohen
		Mean	SD	Mean	SD	Mean	SD	
Age (years)		9.92	1.33	9.89	1.32	9.97	1.35	0.05
BMI (kg/m^2)		18.44	3.31	18.44	3.38	18.44	3.25	0.01
		n	%	n	%	n	%	
Sports	YES	152	67.0	87	73.1	65	60.2	
	NO	75	33.0	32	26.9	43	39.8	
		Mean	SD	Mean	SD	Mean	SD	
Sit-up test (score)		17.45	4.74	17.44	5.35	17.46	3.96	0.04
Horizontal jump test (cm)		134.94	24.78	137.0	25.42	131.52	23.70	0.24
Hand grip strength (kg)		16.44	4.16	16.17	3.97	16.76	4.36	0.04
Countermovement jump test (cm)		19.66	4.15	19.85	4.50	19.45	3.72	0.06
SCR (score)		7.04	6.29	6.38	6.01	7.81	6.54	0.22
SACRT (sec)		19.93	10.24	25.76	14.17	13.10	8.79	1.00
SART (sec)		21.41	10.04	21.10	9.59	21.18	10.59	0.07
SFCT (sec)		17.54	8.82	17.35	9.58	17.75	7.88	0.01
W.REC (score)		6.09	1.57	5.73	1.51	6.52	1.56	0.51

BMI: body mass index; SCR: Stroop correct responses; SACRT: Stroop average correct response time; SART: Stroop average response time; SFCT: Stroop fastest response time; W.REC: word recall.

In the jump tests performed by the participants, specifically in the vertical jump test, the mean distance was 134.94 ± 24.78 cm, and in the CMJ test, it was 19.66 ± 4.15 cm. Additionally, grip strength showed a mean of 16.44 ± 4.16 kg among participants, and the mean

number of repetitions performed in the 30-s abdominal test was 17.45 ± 4.74. It is worth noting that there were no significant differences between genders in the functional tests.

Regarding the control of dependent variables related to cognitive performance, the mean response times for correct answers were found to be 21.41 ± 10.04 in the Stroop Test, with differences observed according to gender. Significant differences were found between boys (6.38 ± 6.01) and girls (7.81 ± 6.54) in the number of correct responses given during the Stroop Test. Significant differences between both sexes were also found in the parameter of fastest correct response in the Stroop Test, with a value of 25.76 ± 147.17 for boys and 13.10 ± 8.79 for girls. The parameters of average response time and average correct response time were similar for both sexes, with a mean value of 21.31 ± 10.04 for average response time and 17.54 ± 8.82 for average correct response time. Principio del formulario.

Regarding memory, which was assessed through the word recall test, females showed a better performance compared to males (6.52 ± 1.56 vs. 5.73 ± 1.51) in terms of the number of words recalled.

The bivariate analysis (Table 2) revealed that none of the dependent variables related to cognitive status were correlated with engaging in sports outside of school, nor with any of the functional jump tests, specifically horizontal jump or vertical jump. Regarding the number of correct responses on the Stroop Test, older age showed a significant correlation with a higher number of correct responses (R = 0.547). Additionally, in relation to physical fitness, a greater number of abdominal repetitions performed in 30 s showed a significant and positive association with a higher number of correct responses on the Stroop Test (R = 0.155). On the other hand, the dependent variable SART (Stroop average response time) showed a significant association with the participants' BMI. Additionally, the number of words recalled also exhibited a significant correlation with the age of the participants. It is worth noting that all dependent variables in the study (cognitive status) showed an association with the age of the participants. Furthermore, at a functional level, higher grip strength correlated with a greater number of correct responses (R = 0.423) and a higher average correct response time on the Stroop Test (R = 0.447). Additionally, grip strength showed a significant and positive correlation with the number of words recalled in the word recall test (R = 0.314). Lastly, increased grip strength was correlated with a shorter average time taken for questions and correct responses on the Stroop Test. Additionally, it is important to evaluate the impact that the chronological age of the subjects could have on the studied variables.

Table 2. Pearson correlation of variables analyzed in this study.

	SCR	SACRT	SART	SFCT	W.REC
Sports	0.046	−0.045	0.091	0.048	0.018
Educational level	0.109	0.004	−0.364 **	−0.066	0.014
Vertical jump	0.082	0.105	−0.133	0.035	−0.089
Sit-up test	0.155 *	0.092	0.115	0.037	0.016
Hand grip	0.423 **	0.447 **	−0.119	−0.273 **	0.314 **
CJT	0.070	0.143	0.010	0.079	−0.002
AGE	0.547 **	0.610 **	−0.150 *	−0.359 **	0.451 **
BMI	0.026	0.036	0.217 **	0.010	0.017
Sex	0.114	−0.058	−0.021	0.023	0.248 **

SCR: Stroop correct responses; SACRT: Stroop average correct response time; SART: Stroop average response time; SFCT: Stroop fastest response time; W.REC: word recall, BMI: body mass index. CJT: countermovement jump test. * $p < 0.05$. ** $p < 0.01$.

4. Discussion

The main objective of the study was to analyze the associations of physical fitness, specifically lower limb strength, abdominal strength, and grip strength, with selective attention and memory. Our key findings showed a significant association of grip strength with cognitive status, selective attention, and memory. On the other hand, abdominal

strength exhibited significant correlations with selective attention as assessed by the Stroop Test, specifically with the number of correct responses. In contrast, neither of the lower limb strength tests (vertical jump or horizontal jump) showed an association with cognitive status in primary school students.

4.1. Selective Attention

Regarding selective attention, our research did not observe significant differences between genders, with only small differences noted in the mean number of correct responses, which were 6.38 ± 6.0 for males and 7.81 ± 6.54 for females. Significant associations were found with the abdominal strength test and grip strength. In a similar study carried out by Cantó [28], two hundred and twenty-four students aged nine and ten years old were evaluated using the ALPHA-fitness battery for physical condition and a test of perception of similarities and differences for selective attention, showing similar results to those found in our research. We found similar results in adolescents; in a study conducted by Kuwamizu, R. [29] in which sixty-seven adolescents underwent grip strength testing using a dynamometer for physical performance and the Stroop Test for cognitive assessment, results similar to those highlighted in our study were found, establishing a significant relationship between both variables. Similarly, Kuwamizu evaluated adolescents' abdominal strength using an isometric test, yielding favorable and similar results to ours, where subjects with higher hand grip test scores also performed better in terms of selective attention as assessed by the Stroop Test.

In the same line of research and with results similar to ours, Altermann, W. [30] conducted a study evaluating strength and attention using the D2 test in 140 students aged fifteen to eighteen years. Upon analyzing the results, it was concluded that there was a relationship between the variables—strength and attention—in adolescents. In contrast to our findings, a study by Domínguez-González, F. et al. [31] evaluated the physical fitness of 85 adolescents using a traditional abdominal test, while selective attention was assessed using the highly validated D2 test. This research did not reveal significant relationships between the two variables (selective attention and abdominal test), possibly due to the smaller sample size, which was notably smaller than that of our study. Similarly, a study by Cabrera Guerrero, D. [32] did not show significant associations between selective attention and an abdominal test in a population of fifteen third-year high school students. Like the previous study, and with more relevance to the current case, the very small sample size could have been the determining factor for the lack of association between these variables.

4.2. Memory

Regarding memory capacity assessed by the Word List Recall Test, females demonstrated a better performance (6.52 ± 1.56) in terms of the number of words recalled compared to males (5.73 ± 1.51). Additionally, a positive and significant association with grip strength was observed ($p < 0.001$). These results are supported by a study conducted by Haapala, E.A. et al. [33], where a significant relationship was established between the studied variables after analyzing grip strength with the "Martin Vigorimeter" and memory with the Raven CPM 30 in a population of 201 girls and 202 boys. The subjects were between 6 and 8 years old. These results are similar to the findings of a study by Muntaner-Mas et al. [34], which evaluated a sample of 422 adolescents (aged 13.35 ± 1.54) using the ALPHA-Fitness Test Battery (Alpha Batteries, Rochdale, UK), including the hand grip test and the N-Back computer test to assess memory. In contrast to our results, a recent study by Mezcua-Hidalgo, A. [35] evaluated 163 adolescents (78 girls and 85 boys) with a mean age of 13.9 ± 1.4 years. They were physically assessed using the ALPHA-Fitness battery test, while memory was assessed with the Ad Hoc test. The results showed no significant associations between muscular strength and the dependent variable, memory. Similarly, in a study by Manríquez et al. [36], where 457 high school students (180 females and 227 males) aged fourteen to nineteen years (15.9 ± 1.27) were evaluated for grip strength using a manual dynamometer and memory using the Benton Form D test, no significant

relationships between these variables were found. This lack of association between variables could be attributed to the low physical fitness of the students, as is highlighted in the respective studies.

4.3. Limitations and Strengths

Admittedly, these findings should be interpreted with caution, as the current research has certain limitations. Perhaps the most important limitation is the cross-sectional design, which prevents the establishment of causal associations. It should also be noted that the size of the sample, although large, did not allow for a balanced and equal distribution of the sexes. Another limitation was conducting the evaluations between December and January. In this regard, we had a minority of primary school students who were not yet 8 years old in December 2023, while others were already 8 years old in January 2023. By 2024, they were already 12 years old. However, and according to the Spanish educational system, they were all primary school students from the first and second cycles of primary school (3rd, 4th, 5th, and 6th grades). Despite the limitations mentioned above, this research has several strengths. Cognitive function was assessed in multiple dimensions using validated questionnaires such as the Stroop Test and the Word List Recall Test. The physical tests used to assess physical function have been validated and are appropriate for the population studied. In relation to the previous paragraph, we found a review [37] in which the existing relationship between cognitive function and academic performance in children between 5 and 13 years old was investigated. The findings of the study support and strengthen our results, proving, although with limited evidence, that favorable results in terms of cognitive performance in this population lead to improvements in the academic performance of children.

4.4. Implications and Future Research

The evidence presented in this paper suggests that strategies aimed at achieving a high level of physical functioning may be successful in adolescents in terms of obtaining better outcomes in selective attention and memory. Further research should validate the associations observed within this particular age group and explore their long-term implications. An avenue for future research would be an analysis of the effects of the exercise program on improvements in both physical fitness and cognitive performance in primary school children.

5. Conclusions

This study reveals that physical fitness levels, especially grip strength and abdominal strength, correlate with selective attention capacity. These findings contribute to our understanding of the connections between these physical and cognitive abilities, suggesting that promoting physical activity during adolescence could be beneficial. Additionally, it was found that grip strength is notably linked to memory capacity. Based on these results, which demonstrate an association between physical and cognitive abilities in adolescents, there is a suggestion regarding the importance of recognizing the role of physical education in teaching and physical activity programs, suggesting the possibility of increasing the hours dedicated to this subject in the school curriculum.

Finally, it is important to note that, due to the descriptive nature of this research, direct causal relationships cannot be established. Therefore, there is an emphasis on the need for future longitudinal studies and randomized controlled trials to determine the causal relationship between physical fitness level and the cognitive aspects mentioned.

Author Contributions: Conceptualization, F.J.G.-E. and F.Á.-S.; methodology, A.B.-M. and M.I.C.-R.; software, J.D.J.-G.; validation, R.C.-R. and J.D.J.-G.; formal analysis, R.C.-R. and J.D.J.-G.; investigation, A.B.-M., J.D.J.-G. and M.I.C.-R. resources, J.D.J.-G.; data curation, F.J.G.-E.; writing—original draft preparation, R.C.-R.; writing—review and editing, F.Á.-S. and J.D.J.-G.; visualization, F.J.G.-E.; supervision, R.C.-R.; project administration, J.D.J.-G.; funding acquisition, J.D.J.-G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of Wales (EADE, Spain) (001/PE/TS/2023).

Informed Consent Statement: Informed consent for participation was obtained from parents, and all assessments were carried out at the school itself.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Acknowledgments: All the authors are grateful for the participation of all those who wished to participate in this study.

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

References

1. Diamond, A. Executive Functions. *Anu. Rev. Psychol.* **2013**, *64*, 135–168. [CrossRef] [PubMed]
2. Wen, Y.; Zhang, X.; Xu, Y.; Qiao, D.; Guo, S.; Sun, N.; Yang, C.; Han, M.; Liu, Z. Cognitive Impairment in Adolescent Major Depressive Disorder with Nonsuicidal Self-Injury: Evidence Based on Multi-indicator ERPs. *Front. Hum. Neurosci.* **2021**, *15*, 637407. [CrossRef] [PubMed]
3. Allen, B.; Waterman, H. Stages of adolescence. *Am. Acad. Pediatr.* **2019**. Available online: https://www.healthychildren.org/English/ages-stages/teen/Pages/Stages-of-Adolescence.aspx (accessed on 20 April 2024).
4. Hobbiss, M.H.; Lavie, N. Sustained Selective Attention in Adolescence: Cognitive Development and Predictors of Distractibility at School. *J. Exp. Child Psychol.* **2023**, *238*, 105784. [CrossRef] [PubMed]
5. Bauer, L.O.; Manning, K.J. Challenges in the detection of working memory and attention decrements among overweight adolescent girls. *Neuropsychobiology* **2016**, *73*, 43–51. [CrossRef] [PubMed]
6. Aragundi-Demera, D.J.; Meza-Intriago, H.A. Estrategia didáctica Para Favorecer La atención Selectiva En El Proceso De Aprendizaje De Los niños De Preparatoria. *MQRInvestigar* **2023**, *7*, 949–964. [CrossRef]
7. Perlman, S.B.; Hein, T.C.; Stepp, S.D.; Consortium, L. Emotional reactivity and its impact on neural circuitry for attention–emotion interaction in childhood and adolescence. *Dev. Cogn. Neurosci.* **2014**, *8*, 100–109. [CrossRef] [PubMed]
8. Rabiner, D.L.; Godwin, J.; Dodge, K.A. Predicting academic achievement and attainment: The contribution of early academic skills, attention difficulties, and social competence. *Sch. Psychol. Rev.* **2016**, *45*, 250–267. [CrossRef]
9. Saltos, L.; Tipan, L.; Andreade, R.; Fonseca, S. Estilos de aprendizaje y la memoria a corto plazo en los estudiantes de educación básica. *Dateh* **2023**, *5*, 6.
10. Hashmi, D.K.; Fayyaz, H.N. Adolescence and Academic Well-being: Parents, Teachers and Students' Perceptions. *J. Educ. Educ. Dev.* **2022**, *9*, 27–47. [CrossRef]
11. Pontifex, M.B.; Raine, L.B.; Johnson, C.R.; Chaddock, L.; Voss, M.W.; Cohen, N.J.; Kramer, A.F.; Hillman, C.H. Cardiorespiratory fitness and the flexible modulation of cognitive control in preadolescent children. *J. Cogn. Neurosci.* **2011**, *23*, 1332–1345. [CrossRef] [PubMed]
12. Hillman, C.H.; Pontifex, M.B.; Raine, L.B.; Castelli, D.M.; Hall, E.E.; Kramer, A.F. The effect of acute treadmill walking on cognitive control and academic achievement in preadolescent children. *Neuroscience* **2009**, *159*, 1044–1054. [CrossRef] [PubMed]
13. Baños, J.C.E.; Casas, A.G.; Escribano, L.G.; Fernández-Marcote, A.R.E.; López, P.T.; Marcos, L.T. Influencia de la actividad física y la capacidad aeróbica sobre el rendimiento académico en la adolescencia: Una revisión bibliográfica. *J. Negat. No Posit. Results* **2018**, *3*, 49–64.
14. Ortega, F.B.; Ruiz, J.R.; Castillo, M.J.; Sjostrom, M. Physical fitness in childhood and adolescence: A powerful marker of health. *Int. J. Obes.* **2008**, *32*, 1–11. [CrossRef] [PubMed]
15. London, R.A.; Castrechini, S. A longitudinal examination of the link between youth physical fitness and academic achievement. *J. Sch. Health* **2011**, *81*, 400–408. [CrossRef] [PubMed]
16. Wittberg, R.A.; Northrup, K.L.; Cottrell, L.A. Children's aerobic fitness and academic achievement: A longitudinal examination of stu- dents during their fifth and seventh grade years. *Am. J. Public Health* **2012**, *102*, 2303–2307. [CrossRef] [PubMed]
17. Coe, D.P.; Peterson, T.; Blair, C.; Schutten, M.C.; Peddie, H. Physical fitness, academic achievement, and socioeconomic status in School–Aged youth. *J. Sch. Health* **2013**, *83*, 500–507. [CrossRef] [PubMed]
18. Páez-Maldonado, J.A.; Reigal, R.E.; Morillo-Baro, J.P.; Carrasco-Beltrán, H.; Hernández-Mendo, A.; Morales, V. Physical Fitness, Selective Attention and Academic Permorfance in a Pre-Adolescent Sample. *Int. J. Environ. Res. Public Health* **2020**, *17*, 6116. [CrossRef] [PubMed]
19. Kao, S.; Westfall, D.R.; Parks, A.C.; Pontifex, M.B.; Hillman, C.H. Muscular and aerobic fitness, working memory, and academic achievement in children. *Med. Sci. Sports Exerc.* **2017**, *49*, 500–508. [CrossRef]
20. Smith, J.J.; Eather, N.; Morgan, P.J.; Plotnikoff, R.C.; Faigenbaum, A.D.; Lubans, D.R. The health benefits of muscular fitness for children and adolescents: A systematic review and meta-analysis. *Sports Med.* **2014**, *44*, 1209–1223. [CrossRef]

21. Sibley, B.A.; Etnier, J.L.; Le Masurier, G.C. Effects of an Acute Bout of Exercise on Cognitive Aspects of Stroop Performance. *J. Sport Exerc. Psychol.* **2006**, *28*, 285–299. [CrossRef]
22. Scarpina, F.; Tagini, S. The stroop color and word test. *Front. Psychol.* **2017**, *8*, 241674. [CrossRef]
23. Runge, S.K.; Craig, B.M.; Jim, H.S. Word Recall: Cognitive Performance Within Internet Surveys. *JMIR Ment. Health* **2015**, *2*, e20. [CrossRef]
24. Castro-Piñero, J.; González-Montesinos, J.L.; Mora, J.; Keating, X.D.; Girela-Rejón, M.J.; Sjostrom, M.; Ruiz, J.R. Valores percentiles de pruebas de campo de fuerza muscular en niños de 6 a 17 años: Influencia del estado ponderal. *J. Strength Cond. Res.* **2011**, *23*, 2295–2310. [CrossRef] [PubMed]
25. Castro-Piñero, J.; Ortega, F.B.; Artero, E.G.; Girela-Rejón, M.J.; Mora, J.; Sjostrom, M.; Ruiz, J.R. Evaluación de la fuerza muscular en jóvenes: Utilidad del salto de longitud de pie como índice general de aptitud muscular. *J. Strength Cond. Res.* **2022**, *24*, 1810–1817. [CrossRef] [PubMed]
26. Watanabe, T.; Owashi, K.; Kanauchi, Y.; Mura, N.; Takahara, M.; Ogino, T. The short-term reliability of grip strength measurement and the effects of posture and grip span. *J. Hand Surg.* **2005**, *30*, 603–609. [CrossRef]
27. Gomez-Bruton, A.; Gabel, L.; Nettlefold, L.; Macdonald, H.; Race, D.; McKay, H. Estimation of Peak Muscle Power from a Countermovement Vertical Jump in Children and Adolescents. *J. Strength Cond. Res.* **2019**, *33*, 390–398. [CrossRef]
28. Cantó, E.G.; Guillamón, A.R.; López, P.J.C.; Soto, J.J.P.; Palomares, A.G.; García, J.E.M. Relación entre condiciones físicas y atención cognitiva de los niños de educación primaria. *EmásF Rev. Digit. Educ. Física* **2021**, *70*, 95–113.
29. Kuwamizu, R. Muscle Strength and Executive Function: High Grip Strength Young Males Can Get a Grip on Stroop Task. *Bull. Yokohama City Univ.* **2021**, *72*, 177–192.
30. Altermann, W.; Gröpel, P. Physical fitness is related to concentration performance in adolescents. *Sci. Rep.* **2024**, *14*, 587. [CrossRef]
31. Domínguez-González, F.; Moral-Campillo, L.; Reigal, R.E.; Hernández-Mendo, A. Condición física y atención selectiva en una muestra preadolescente. *Cuad. Psicol. Deporte* **2018**, *18*, 33–42.
32. Cabrera Guerrero, D.R. Actividad Física y Rendimiento Cognitivo, Estudiantes de Tercero de Secundaria. IE José St. Chocano Cutervo. 2022. Available online: http://publicaciones.usanpedro.edu.pe/bitstream/handle/20.500.129076/22386/Tesis_74635.pdf?sequence=1&isAllowed=y (accessed on 20 April 2024).
33. Haapala, E.A.; Lintu, N.; Väistö, J.; Robinson, L.E.; Viitasalo, A.; Lindi, V.; Lakka, T.A. Associations of Physical Performance and Adiposity with Cognition in Children. *Med. Sci. Sports Exerc.* **2015**, *47*, 2166–2174. [CrossRef]
34. Muntaner-Mas, A.; Mora-Gonzalez, J.; Cabanas-Sánchez, V.; Pintado, L.B.; Salmon, J.; Hillman, C.H.; Castro-Piñero, J.; Perales, J.C.; Veiga, O.L.; Esteban-Cornejo, I. Prospective associations between physical fitness and executive function in adolescents: The UP&DOWN study. *Psychol. Sport Exerc.* **2022**, *61*, 102203.
35. Mezcua-Hidalgo, A.; Ruiz-Ariza, A.; Ferreira Brandão De Loureiro, V.A.; Martínez-López, E.J. Capacidades físicas y su relación con la memoria, cálculo matemático, razonamiento lingüístico y creatividad en adolescentes (Physical capacities and their relation with memory, mathematical calculation, linguistic reasoning, and creativity in adolescents). *Retos* **2019**, *37*, 473–479. [CrossRef]
36. Manríquez, A.B.; Torres, F.Q.; Soto, J.; Necuñir, C.T.; Cid, F.M. Relación de la capacidad aeróbica, fuerza prensil y potencia de salto con la memoria de trabajo y rendimiento academico de estudiantes de secundaria de santiago de chile. *EmásF Rev. Digit. Educ. Física* **2019**, *58*, 63–74.
37. Donnelly, J.E.; Hillman, C.H.; Castelli, D.; Etnier, J.L.; Lee, S.; Tomporowski, P. Actividad física, estado físico, función cognitiva y rendimiento académico en niños: Una revisión sistemática. *Ejerc. Deport. De Cienc. Médicas.* **2016**, *48*, 1197–1222.