

Article

Exploring the Associations Between Organized Sports Participation, Body Composition and Dietary Habits in a Sample of Greek Adolescents

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Abstract

(1) Background: Adolescence is a critical period for the development of health-related behaviors, including dietary habits and physical activity. This cross-sectional study examined the associations between participation in organized sports, nutrient intake, and body composition in a sample of Greek adolescents. (2) Methods: A total of 224 adolescents aged 12–18 years from schools in the Attica region, Greece, participated in the study. Physical activity and organized sports participation were assessed using a validated questionnaire. Body composition was estimated using bioelectrical impedance analysis, and dietary intake was evaluated using three-day self-reported food records analyzed with Cronometer® nutrition analysis software. (3) Results: Boys had higher fat-free mass and basal metabolic rate and lower fat-mass percentage than girls. Organized sports participation was common and differed by sex, with boys reporting higher participation and greater adherence to physical activity recommendations than girls. Organized sports participation was associated with differences in selected nutrient intakes, particularly among late adolescents; however, several differences were attenuated when nutrient intake was standardized per 1000 kcal, suggesting that part of the observed pattern may reflect differences in total energy intake. (4) Conclusions: These cross-sectional findings suggest that age-defined adolescent stage and organized sports participation are associated with differences in sports involvement, body composition, and nutrient intake among Greek adolescents; however, causal relationships cannot be established, and the findings should be interpreted as associations.

Keywords: adolescents; sports participation; exercise; body composition; Mediterranean diet; nutrient intake

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1. Introduction

Adolescence is the transition from childhood to adulthood and involves interrelated biological, hormonal, cognitive, and psychosocial changes. This developmental period is characterized by rapid growth, increasing autonomy, and the establishment of health behaviors that may persist into adulthood. The World Health Organization (WHO) defines adolescence as the period from 10 to 19 years of age, while emerging adulthood may extend into the early twenties [1]. The Lancet Commission further conceptualizes adolescence as a period with distinct sub-phases that reflect changes in physiology, cognition, and social development [2,3].

Puberty is driven by hormonal changes that enable reproductive maturation and contribute to broader physical and psychosocial development. These changes may also influence mood, peer sensitivity, and social awareness, making adolescence a key window for interventions that support healthy development [1]. The activation of the hypothalamic–pituitary–gonadal axis initiates the endocrine cascade of puberty. Gonadotropin-releasing hormone stimulates pituitary secretion of luteinizing hormone and follicle-stimulating hormone, which in turn act on the gonads to increase sex-steroid production, including testosterone in boys and estrogens in girls [4].

The onset of puberty is accompanied by increased energy and nutrient requirements. The energy values presented here should be interpreted as reference estimates rather than fixed requirements, because adolescent energy needs vary according to age, sex, body size, growth rate, and physical activity level. Reported reference values indicate energy needs of approximately 2500 kcal/day for girls and 3000 kcal/day for boys [5]. These requirements should be met primarily through nutrient-dense foods such as whole grains, legumes, fruits, and vegetables, rather than foods high in saturated fat, added sugar, and salt. Regular breakfast consumption, home-prepared meals, appropriate portion sizes, reduced screen time, and habitual physical activity are also central components of a healthy adolescent lifestyle [6]. Nutrients are commonly classified as macronutrients and micronutrients [7]. Carbohydrates, proteins, and lipids provide energy and structural substrates for growth and tissue development [8], whereas vitamins and minerals are required in smaller amounts but are essential for metabolic regulation and physiological integrity [9]. Inadequate intake of either macronutrients or micronutrients may compromise development, particularly during periods of rapid growth [10,11]. During adolescence, adequate macronutrient and micronutrient intake is essential for growth, body-composition development, and physical activity. In the context of organized sports participation, nutrient-dense dietary patterns may help adolescents meet higher energy and nutrient needs, whereas diets rich in added sugars, saturated fat, and energy-dense foods may compromise diet quality. Therefore, the present study focuses on dietary habits and nutrient intake in relation to organized sports participation rather than presenting nutritional recommendations in isolation.

Adolescent obesity prevention is closely linked to the rationale for examining organized sports participation, because structured sports settings may support regular physical activity and may coexist with healthier dietary behaviors. Examining body composition and nutrient intake among adolescents who participate in organized sports and those who do not may therefore provide useful information for school-based and public-health strategies.

Childhood and adolescent overweight remains a major concern in Europe. The WHO has reported substantial increases in overweight and obesity among children and adolescents over recent decades, and excess body weight during childhood frequently persists into adolescence and adulthood [12–17]. Dietary patterns among adolescents often include high intakes of energy-dense foods rich in saturated fat, sugar, and salt, together with low consumption of vegetables, fruits, and unprocessed grains [18].

Physical inactivity is a major risk factor for poor health and well-being [19–21]. Evidence-based policies and interventions are therefore needed to promote physical activity across the population, with particular emphasis on children and adolescents [22]. Sedentary behavior is defined as any waking behavior with an energy expenditure of ≤ 1.5 metabolic equivalents while sitting, reclining, or lying down [23]. Common sedentary behaviors include television viewing, smartphone and tablet use, video gaming, computer use, reading or studying while seated, and passive transport.

The WHO Global Action Plan on Physical Activity 2018–2030 established a global target to reduce physical inactivity by 15% by 2030 [24]. In Greece, data from the National Action Plan for Children's Health (EYZHN) showed that, in 2015, the prevalence of overweight and obesity was 22.2% and 9.0% among boys and 21.6% and 7.5% among girls, respectively [25]. These conditions have been associated with dietary habits, low adherence to the Mediterranean diet, insufficient sleep, sedentary behavior, and low physical activity. Abdominal obesity is also prevalent among Greek children. Hassapidou et al. reported that approximately one quarter of 7-year-old children had abdominal obesity, placing Greece among countries with high childhood abdominal-obesity prevalence [26].

Nevertheless, childhood and adolescent obesity remain important public-health concerns in Greece and across Europe. More recent WHO COSI sixth-round data from 2022 to 2024 indicate that overweight and obesity remain prevalent among school-aged children in the WHO European Region, with southern European countries, including Greece, continuing to show a high burden [27]. Because these recent COSI data mainly concern children aged 7–9 years rather than adolescents, they are used here only as contextual evidence and are not overgeneralized to the present adolescent sample. Health-related physical fitness in youth refers to the capacity to engage in physical activity and includes physiological characteristics linked to lower chronic-disease and premature-mortality risk [28]. Its main components include cardiorespiratory fitness, musculoskeletal fitness, flexibility, speed, agility, balance, and other aspects of motor competence.

A growing body of evidence shows that health-related physical fitness, particularly cardiorespiratory fitness and muscular strength, is associated with favorable physical, emotional, mental, and social health outcomes in young people [29–31]. Higher physical activity has also been associated with better health-related quality of life, whereas sedentary behavior has been associated with poorer outcomes [32]. Exercise is an effective strategy for supporting a healthy lipid profile during adolescence. Regular physical activity can help reduce low-density lipoprotein cholesterol, triglycerides, and the total cholesterol-to-HDL cholesterol ratio in children and adolescents [33–37].

Regular physical activity also supports broader aspects of health and quality of life. Children and adolescents who participate consistently in physical activity tend to show better physical, psychological, and mental-health outcomes [38,39]. Despite these benefits, the WHO reports that approximately 80% of adolescents worldwide do not meet recommended physical activity levels, defined as at least 60 min per day of moderate-to-vigorous-intensity physical activity for school-aged children and adolescents [40–42].

Although previous studies have examined physical activity, obesity, and dietary habits in adolescents, limited evidence is available regarding how organized sports participation is associated with both detailed nutrient intake and body-composition characteristics among Greek adolescents. In addition, few studies have explored whether these associations differ by sex and age-defined adolescent stage. The present study was designed to address this gap by examining the associations between organized sports participation, adherence to physical activity recommendations, dietary intake, and body composition in a sample of Greek adolescents. Specifically, the study compared adolescents who participated in organized sports with those who did not. Because pubertal development was not

directly assessed, chronological age groups are referred to as age-defined adolescent stages rather than pubertal stages.

2. Materials and Methods

2.1. Study Design

This cross-sectional study examined dietary habits and body composition in adolescents, with a specific focus on regular participation in organized sports. Because of the observational design, the study evaluated associations only and was not designed to infer causal effects. The study protocol was approved by the Bioethics Committee of the University of West Attica (reference number: 112168/14-12-2021).

2.2. Study Procedure

After obtaining the required permissions from the Ministry of Education (reference number: 1117/22-02-2022), the research team contacted 20 school principals to present the study objectives and request school participation. To obtain a geographically diverse sample from the Attica basin, schools from northern, southern, eastern, and western areas of Attica were approached.

Of the 20 schools contacted, 14 schools (13 public and 1 private) agreed to participate. The research team was permitted to present the study briefly (approximately 5–7 min) to classes without disrupting the educational program. In total, 500 students received study information and parental consent forms, which they were asked to return within two weeks.

Students who returned both signed parental consent and personal assent forms completed the study questionnaires and underwent body-composition assessment during school hours. The recruitment and participation process is summarized in Figure 1. Data collection was conducted from March 2022 to the end of 2023. Of the 500 students who initially received study information and consent forms, 224 were included in the final analysis; no data were available from non-participants to compare them with the final study sample. Because participation depended on the return of signed parental consent and adolescent assent forms, selection bias cannot be excluded. Adolescents or families with greater interest in health, nutrition, or sports may have been more likely to participate. No information was collected from students who did not participate; therefore, participants could not be compared with non-participants.

2.3. Study Participants

A total of 224 adolescents provided parental consent and personal assent and were included in the study. Eligibility criteria were age 12–18 years, sufficient knowledge of the Greek language, and submission of a valid pediatric health certificate. Exclusion criteria included chronic disease, current pharmacological treatment, and recent COVID-19 or other viral infection. For this criterion, recent infection was defined as COVID-19 or another acute viral infection during the previous four weeks.

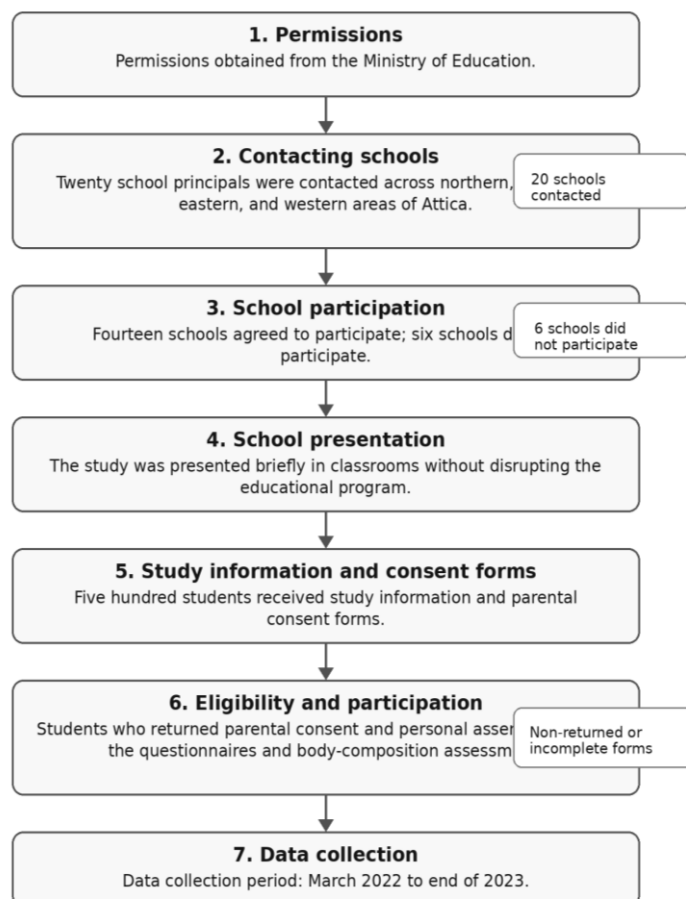


Figure 1. Flowchart describing the selection and participation of the study participants.

2.4. Variables and Instruments

2.4.1. Organized Sports Participation and Physical Activity Assessment

Physical activity and daily exercise engagement were assessed using a validated physical activity questionnaire that evaluated daily routines and participation in organized sports, including team sports and gym-based activities [43]. The questionnaires used in the study are provided in Supplementary Materials Tables S1 and S2. Based on their responses, participants were classified into four groups: (1) team sports; (2) indoor/gym-based individual activities; (3) both team and gym-based activities; and (4) no organized exercise. Organized exercise was defined as weekly training conducted by certified trainers in sports clubs outside school physical education. The team-sports group included adolescents participating in structured weekly training in sports such as soccer, basketball, or volleyball. The gym-based group included individual activities such as gymnastics, martial arts, or weightlifting. The combined group included adolescents who participated in both team and gym-based activities. Because physical activity was assessed using a self-reported questionnaire, responses may be affected by recall bias and social desirability bias, potentially leading to overestimation of physical activity levels. Participants were asked to report participation in structured weekly training outside school physical education; however, exact training frequency, duration, weekly training volume, and competitive level were not systematically quantified in the present study.

The questionnaire was administered using standardized instructions. It was selected because previous validation work has supported its use for assessing physical activity patterns in adolescents [43]. Because the present analysis used categorical participation variables rather than a single psychometric scale score, internal-consistency coefficients

were not the primary reliability indicator; instead, the relevant validation evidence and standardized administration procedures were reported. The questionnaire was used as a validated instrument for classifying adolescent physical-activity patterns and organized sports participation. Because the variables derived for the present analyses were categorical grouping variables rather than a single summed psychometric scale, Cronbach's alpha was not calculated for the present dataset; reliability was supported by use of the previously validated instrument, standardized administration, and the same classification procedure for all participants.

2.4.2. Dietary Intake Assessment

Food Diary (Food Record)

Food records are prospective dietary assessment tools used to document all foods and beverages consumed over a defined period, typically 3–7 days. Participants are instructed to record intake in real time or shortly after consumption, thereby reducing recall bias [44]. In the present study, participants completed detailed food records for two non-consecutive weekdays and one non-consecutive weekend day. Dietary intake was calculated as the average of the three recorded days. Although three-day food records are a recognized prospective dietary assessment method, they may not fully capture habitual dietary intake. This limitation is particularly relevant for micronutrients, which can exhibit substantial day-to-day variability. In addition, seasonal variation in food availability and consumption may have influenced reported intake, particularly for fruit, vegetable, and micronutrient consumption.

Food records and anthropometric/body-composition measures are not psychometric scales and therefore are not evaluated using internal-consistency coefficients in the same way as questionnaire scales. Reliability was supported by standardized recording instructions, use of the same dietary-analysis procedure for all participants, and standardized anthropometric measurement procedures.

The food-record questionnaire captured detailed information on foods and beverages consumed, including quantity, cooking method, brand name when applicable, place of consumption, concurrent activities, and dining companions. All dietary records were entered into Cronometer® nutrition analysis software version 4.46, which provides detailed macro- and micronutrient composition data. Nutrient values were derived from the USDA National Nutrient Database for Standard Reference and from nutrient values incorporated into the Cronometer® platform. When traditional Greek foods, mixed dishes, or local recipes were not directly available in the database, the closest matching food item was selected, or recipes were entered manually based on the reported ingredients and preparation methods. This procedure was applied consistently, although possible inaccuracies in the nutrient composition of local homemade foods cannot be excluded.

Final dietary data were exported to Excel spreadsheets, and nutrient analyses were conducted for each participant using the mean intake across the three recorded days.

2.4.3. Anthropometric and Body-Composition Assessment

Standing height was measured without shoes to the nearest 0.1 cm using a portable stadiometer (Seca 213, Seca, Hamburg, Germany). Body weight and body composition were assessed using a portable bioelectrical impedance analysis device (InBody H20B Body Fat Analyzer, Seoul, Republic of Korea). Bioelectrical impedance analysis was selected because it is a practical, non-invasive, portable, and feasible method for body-composition assessment in school-based adolescent research, where reference methods such as dual-energy X-ray absorptiometry (DXA) are often not logistically feasible. The body-composition variables extracted for the present analysis were fat-free mass (FFM), fat-mass percentage (FM%), and basal metabolic rate (BMR). InBody results were checked

and managed through the my InBody web platform (<http://myinbody.com/qrintro.htm?CID=G52017237>; accessed on 12 March 2024). Body mass index (BMI) was calculated as body weight in kilograms divided by height in meters squared (kg/m^2). When required for descriptive classification, BMI-for-age percentiles were interpreted according to the WHO growth-reference cut-offs for children and adolescents aged 5–19 years: underweight (<5th percentile), normal weight (5th to <85th percentile), overweight (85th to <95th percentile), and obesity (≥ 95 th percentile) [18].

All anthropometric and BIA measurements were conducted according to the same standardized protocol in the school setting, using the same equipment and procedures for all participants. Participants were measured during school hours under standardized field conditions, using the same device and protocol. They were instructed to avoid intense exercise and large meals before assessment; however, hydration status was not directly measured, and residual variability related to hydration or recent food/fluid intake cannot be excluded.

2.5. Statistical Analysis

Statistical analysis was performed for the total study population and for predefined subgroups according to sex, age-defined adolescent stage, and level of sports engagement. Participants were classified as early adolescents aged 12–15 years and late adolescents aged 16–18 years. This classification was based solely on chronological age and should not be interpreted as a direct assessment of pubertal development or biological maturation. Sports engagement was examined both as a binary variable, comparing adolescents participating in any organized exercise with those reporting no organized exercise, and as a categorical variable according to type of activity: team sports, indoor/gym-based activities, combined team and gym-based activities, or no organized exercise. Adherence to physical activity recommendations was also evaluated according to whether participants reported at least 60 min per day of moderate-to-vigorous-intensity physical activity.

Continuous variables were assessed for normality using the Kolmogorov–Smirnov test. Because most anthropometric, body-composition, and dietary variables were not normally distributed, results are presented as medians and interquartile ranges. Categorical variables are presented as absolute frequencies and percentages.

Comparisons between two independent groups, such as boys versus girls or adolescents with versus without organized exercise, were performed using the Mann–Whitney U test. Comparisons across more than two exercise groups were conducted using the Kruskal–Wallis test. When statistically significant differences were detected in multi-group comparisons, Dunn’s post hoc test was applied for pairwise comparisons. Differences in categorical variables, including sex distribution, exercise participation, and adherence to physical activity recommendations, were evaluated using the chi-square test.

No formal correction for multiple testing was applied; therefore, the dietary analyses should be interpreted as exploratory, and the possibility of type I error cannot be excluded.

Dietary intake was analyzed both as absolute daily intake and as nutrient intake standardized per 1000 kcal, in order to account for differences in total energy intake between participants. All statistical tests were two-tailed, and statistical significance was set at $p < 0.05$. Analyses were performed using IBM SPSS Statistics version 25.0. Expressing nutrient intake per 1000 kcal allowed comparison of nutrient density and helped distinguish whether observed differences reflected higher total food intake or differences in dietary composition. Accordingly, these p -values were treated as nominal indicators of possible associations and were interpreted cautiously in relation to the overall pattern of findings.

3. Results

3.1. Population Characteristics

This cross-sectional study included 224 adolescents aged 12–18 years from public and private schools in the Attica region; 95 participants (42.4%) were girls. Most participants were enrolled in the three grades of Lyceum. There were no statistically significant differences between boys and girls in school-grade distribution. The median age was 16.0 years (interquartile range: 14.0–16.0), and most participants reported Greek nationality.

Table 1a,b present anthropometric and body-composition characteristics by sex, total population and age-defined adolescent stage. To improve readability, anthropometric variables and body-composition variables are now presented separately.

Table 1. (a) Anthropometric variables by sex and age-defined adolescent stage. (b) Body-composition variables by sex and age-defined adolescent stage.

(a)									
Variables	Total Population (n = 224)			Early Adolescence (n = 57)			Late Adolescence (n = 167)		
	All (n = 224)	Boys (n = 129)	Girls (n = 95)	All (n = 57)	Boys (n = 32)	Girls (n = 25)	All (n = 167)	Boys (n = 97)	Girls (n = 70)
Age (years)	16.0 (14.0–16.0)	16.0 (14.5–16.0)	16.0 (14.0–16.0)	13.0 (12.0–14.0)	13.0 (12.2–14.0) #	13.0 (12.0–14.0) \$	16.0 (15.0–16.0)	16.0 (15.0–16.00) #	16.0 (15.0–17.0) \$
Height (m)	1.69 (1.61–1.76)	1.76 (1.70–1.80) *	1.62 (1.58–1.66) *	1.63 (1.58–1.75)	1.72 (1.59–1.79) *#	1.61 (1.57–1.62) *	1.71 (1.64–1.77)	1.76 (1.72–1.80) *#	1.63 (1.59–1.67) *
Weight (kg)	60.5 (52.7–68.5)	66.6 (58.5–73.1) *	53.6 (49.9–59.4) *	54.0 (47.9–62.7)	56.8 (49.7–65.3) #	50.8 (45.4–57.9) \$	63.7 (54.3–70.6)	68.0 (61.8–75.3) *#	54.4 (51.0–60.6) *\$
BMI (kg/m ²)	20.8 (19.3–22.9)	21.1 (19.4–23.2)	20.6 (19.2–22.5)	19.6 (17.7–20.9)	19.5 (17.6–20.4) #	20.0 (17.8–22.2)	21.2 (19.8–23.2)	21.4 (20.2–23.9) *#	20.7 (19.4–22.7) *
(b)									
Variables	Total Population (n = 224)			Early Adolescence (n = 57)			Late Adolescence (n = 167)		
	All (n = 224)	Boys (n = 129)	Girls (n = 95)	All (n = 57)	Boys (n = 32)	Girls (n = 25)	All (n = 167)	Boys (n = 97)	Girls (n = 70)
FFM (kg)	26.7 (22.0–32.8)	32.1 (27.8–35.1) *	22.0 (20.1–23.9) *	24.0 (20.3–28.7)	26.5 (21.5–32.5) *#	22.0 (20.0–24.0) *	28.9 (22.3–33.4)	32.6 (29.9–36.0) *#	22.1 (20.3–23.9) *
FM (%)	18.0 (12.3–24.7)	14.3 (10.1–18.2) *	24.1 (19.8–28.6) *	16.5 (8.3–25.2)	10.05 (7.00–17.3) *#	22.3 (16.4–26.9) *	18.2 (13.1–24.4)	14.6 (11.6–18.2) *#	25.0 (20.1–29.6) *
BMR (kcal/day)	1419.0 (1249.0–1628.0)	1599.0 (1451.5–1720.5) *	1249.0 (1179.5–1314.5) *	1312.0 (1182.5–1487.5)	1405.0 (1223.0–1621.7) *#	1248.0 (1175.0–1313.0) *	1501.0 (1257.5–1645.2)	1622.0 (1524.2–1741.2) *#	1250.0 (1183.0–1319.2) *

Results are presented as medians (25th–75th Percentile). Symbol definitions: * $p \leq 0.05$ for between-gender comparisons within the same adolescent stage. # $p \leq 0.05$ for comparisons between early adolescent boys and late adolescent boys. \$ $p \leq 0.05$ for comparisons between early adolescent girls and late adolescent girls. BMI: Body mass index. FFM: Fat-free mass. FM (%): Percent of fat mass. BMR: Basal metabolic rate.

In the total sample, boys were taller, heavier, and had higher fat-free mass (FFM) and basal metabolic rate (BMR) than girls, whereas girls had higher fat-mass percentage.

When boys and girls were compared within the same adolescent stage, early-adolescent boys were taller and had higher FFM and BMR than early-adolescent girls, whereas early-adolescent girls had higher fat-mass percentage. In late adolescence, boys had higher height, weight, BMI, FFM, and BMR than girls, while girls had higher fat-mass percentage.

Differences were also observed between early and late adolescence within each sex. Early-adolescent boys had lower age, height, weight, BMI, FFM, fat-mass percentage, and BMR than late-adolescent boys. Among girls, late adolescents had higher age and body weight than early adolescents. The lower fat-mass percentage observed among early-adolescent boys compared with late-adolescent boys was unexpected and should be interpreted cautiously. This pattern may reflect heterogeneity in chronological age, biological maturation, body size, sports participation, or sample-specific variation, particularly because pubertal status was not directly assessed.

3.2. Organized Sports Participation

A substantial proportion of participants (79.1%) reported participation in organized physical activity, including team sports, gym-based individual activities, or both (Table 2). Sex differences were evident: 33.7% of girls reported no organized exercise compared with 11.6% of boys ($p < 0.001$). The high prevalence of organized sports participation should be interpreted cautiously. It may partly reflect regional characteristics of the Attica schools included in the study, school-level factors, and potential selection bias, because adolescents with greater interest in health, nutrition, or sports may have been more likely to participate.

Table 2. Participation by gender in different types of exercise in early and late adolescents ($n(\%)$).

Exercise Type of Exercise	All Participants ($n = 224$)			Early Adolescence ($n = 57$)			Late Adolescence ($n = 167$)		
	All ($n = 224$)	Boys ($n = 129$)	Girls ($n = 95$)	All ($n = 57$)	Boys ($n = 32$)	Girls ($n = 25$)	All ($n = 167$)	Boys ($n = 97$)	Girls ($n = 70$)
No Exercise	47 (21.0)	15 (11.6) *	32 (33.7) *	3 (5.3)	1 (3.1) **	2 (8.0) *\$	44 (26.3)	14 (14.4) **	30 (42.9) *\$
Team Sports	79 (35.3)	56 (43.4) *	23 (24.2) *	30 (52.6)	21 (65.6) **	9 (36.0) *\$	49 (29.3)	35 (36.1) **	14 (20.0) *\$
Indoor Gym Sports	75 (33.5)	43 (33.3) *	32 (33.7) *	14 (24.6)	5 (15.6) **	9 (36.0) *\$	61 (36.5)	38 (39.2) **	23 (32.9) *\$
Team and Gym	23 (10.3)	15 (11.6) *	8 (8.4) *	10 (17.5)	5 (15.6) **	5 (20.0) *\$	13 (7.8)	10 (10.3) **	3 (4.3) *\$
MVPA ≥ 60 min/day	172 (76.8)	113 (87.6) *	59 (62.1) *	51 (89.5)	30 (93.8) **	21 (84.0) *\$	121 (72.5)	83 (85.6) **	38 (54.3) *\$
MVPA < 60 min/day	52 (23.2)	16 (12.4) *	36 (37.9) *	6 (10.5)	2 (6.3) **	4 (16.0) *\$	46 (27.5)	14 (14.4) **	32 (45.7) *\$

Results are presented as $n(\%)$. Symbol definitions: * $p \leq 0.05$ for between-gender comparisons. # $p \leq 0.05$ for comparisons between early adolescent boys and late adolescent boys. \$ $p \leq 0.05$ for comparisons between early adolescent girls and late adolescent girls. MVPA: Moderate-to-vigorous-intensity physical activity.

Among all participants, 35.3% participated in team sports, 33.5% in gym-based individual activities, and 10.3% in both team and gym-based activities. Boys more frequently reported team-sport participation, whereas girls more frequently reported gym-based individual activities.

The most common team sports among boys were basketball and soccer. Among girls, the most common activities were track and field and volleyball. For gym-based individual activities, boys most often reported weightlifting, aerobic and martial arts, whereas girls most often reported martial arts, dance and gymnastics.

Regarding adherence to WHO physical activity recommendations, 76.8% of the total sample reported at least 60 min per day of moderate-to-vigorous-intensity physical activity (MVPA). A higher proportion of boys met this recommendation (87.6%) compared with girls (62.1%). This relatively high proportion should be interpreted cautiously, given the self-reported nature of the physical activity assessment and the possibility of recall and social desirability bias. This proportion is higher than that reported in many international studies. Therefore, it should not be interpreted as an objectively measured prevalence estimate because physical activity was self-reported and may have been overestimated due to recall and social desirability bias.

It should be noted that the subgroup of early adolescents without organized exercise participation was extremely small ($n = 3$ in total; one boy and two girls). Therefore, subsequent subgroup analyses involving this group should be interpreted descriptively and with extreme caution, and no strong inferential conclusions should be drawn from these cells. For this reason, statistical comparisons involving early-adolescent non-participants in organized exercise were not emphasized as definitive inferential findings. The main interpretation of dietary associations focuses on the more adequately represented late-adolescent subgroups.

3.3. Dietary Habit Variables According to Participation in Sport Activities

To improve readability, the presentation of dietary results was focused on the most clinically and nutritionally relevant patterns rather than on an exhaustive interpretation of every nutrient-specific comparison. The main text therefore emphasizes energy intake, protein, fiber, fat quality, and selected micronutrients relevant to adolescent growth and sports participation, whereas detailed nutrient-level values are retained in the Tables for transparency and may be transferred to Supplementary Material according to journal formatting requirements.

Table 3a,b compare dietary intake between active and inactive adolescents by sex and age-defined adolescent stage; detailed vitamin and mineral variables are provided in Supplementary Tables S3 and S4. Among late-adolescent boys, participation in organized exercise was associated with higher total energy intake and higher intake of protein, monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), omega-6 fatty acids, pantothenic acid (vitamin B5), pyridoxine (vitamin B6), vitamins C, E, and K, total fat, cholesterol, and zinc compared with no organized exercise. Among late-adolescent girls, participation in organized exercise was associated with higher intake of fiber, starch, thiamine (vitamin B1), riboflavin (vitamin B2), pyridoxine (vitamin B6), vitamin D, copper, magnesium, and manganese. Because several nutrient comparisons were performed across sex, age-defined adolescent stage, and activity categories, the nutrient-specific results should be interpreted cautiously as exploratory findings rather than confirmatory evidence. Because of the very small number of early adolescents without organized exercise participation, the interpretation of dietary associations focuses primarily on the more adequately represented late-adolescent subgroups. Accordingly, nutrients showing isolated statistically significant differences without clear biological or clinical relevance were not overemphasized in the narrative interpretation. The main interpretation focuses on consistent dietary patterns and on nutrients of established relevance during adolescence, including protein, fiber, vitamin D, calcium, magnesium, iron, and zinc.

Table 3. (a) Energy and macronutrient variables compared to organized sports participation in early and late adolescents by gender. (b) Carbohydrate subtypes and lipid-related variables compared to organized sports participation in early and late adolescents by gender.

(a)								
Early Adolescents (n = 57)					Late Adolescents (n = 167)			
Eating Habits	Boys (n = 32)		Girls (n = 25)		Boys (n = 97)		Girls (n = 70)	
	No Exercise (n = 1)	Any Exercise (n = 31)	No Exercise (n = 2)	Any Exercise (n = 23)	No Exercise (n = 14)	Any Exercise (n = 83)	No Exercise (n = 30)	Any Exercise (n = 40)
Energy (Kcal)	2047.24	1859 (1674.3–2184)	1897.05	1628.04 (1373.18–1730.63)	1834.35 (1586.42–2220.9) *	2193.4 (1763.5–2542.36) *	1655.62 (1373.39–1861.02)	1776.22 (1596.72–2006.6)
CHO (gr)	242.76	216.3 (185.72–234.93)	233.71	164.48 (145.73–187.82)	215.4 (168.59–238.65)	220.3 (169.74–262.36)	166.44 (139.05–202.45)	202.89 (156.94–226.2)
Fat (gr)	83.63	77.87 (64.74–90)	73.99	66.13 (52.43–78.77)	77.68 (63.14–95.11) *	94.02 (74.8–117.3) *	74.75 (62.01–85.17)	73.86 (68.95–86.51)
Protein (gr)	80.88	80.1 (69.88–101.15)	74.06	65.57 (54.72–89.91)	77 (62.88–90.57) *	101.69 (78.15–131.38) *	69.69 (56.29–79.42)	76.24 (65.28–91.1)
CHO (%)	0.47	0.46 (0.42–0.48)	0.49	0.44 (0.38–0.47)	0.43 (0.39–0.52)	0.41 (0.36–0.46)	0.42 (0.37–0.46)	0.44 (0.39–0.48)
Fat (%)	0.36	0.37 (0.33–0.39)	0.35	0.36 (0.3–0.4)	0.36 (0.32–0.43)	0.39 (0.35–0.43)	0.4 (0.36–0.44)	0.38 (0.35–0.4)
Protein (%)	0.15	0.17 (0.15–0.18)	0.15	0.17 (0.14–0.2)	0.16 (0.14–0.2)	0.18 (0.15–0.22)	0.15 (0.13–0.19)	0.17 (0.14–0.19)
(b)								
Early Adolescents (n = 57)					Late Adolescents (n = 167)			
Eating Habits	Boys (n = 32)		Girls (n = 25)		Boys (n = 97)		Girls (n = 70)	
	No Exercise (n = 1)	Any Exercise (n = 31)	No Exercise (n = 2)	Any Exercise (n = 23)	No Exercise (n = 14)	Any Exercise (n = 83)	No Exercise (n = 30)	Any Exercise (n = 40)
Starch (gr)	52.82	91.1 (71.86–118)	92.69	70.57 (38.43–81.97)	87.92 (57.85–97.9)	88.39 (61.87–114.69)	64.65 (50.65–82.54) #	82.55 (63.1–103.9) #
Fiber (gr)	21.95	17.66 (13.18–24.02)	21.36	16.64 (13.08–21.74)	23.33 (11.76–28.4)	17.8 (13.4–25.6)	14.16 (10.71–19.42) #	18.77 (13.34–23.02) #
Sugars (gr)	78.03	54.2 (41.8–80.18)	68.13	51.56 (47.3–73.44)	57.63 (34.85–60.6)	61.5 (43.7–83.3)	44.45 (35.15–62.65)	60.85 (36.27–71.57)
Simple sugars (gr)	217.98	194.29 (168.03–219.45)	210.76	146.32 (135.14–175.44)	188.48 (157.29–207.73)	195.9 (153.27–243.68)	151.03 (130.91–184.29)	178.81 (144.25–208.42)
Chol (mg)	280.79	261.62 (110.3–392.04)	75.73	216.29 (119.34–366.15)	217.95 (168.09–332.6) *	358.57 (235.4–462.74) *	192.95 (150.8–242.71)	209.11 (147.87–292.27)
MUFA (gr)	31.04	23.97 (18.38–32.7)	17.44	23.14 (15.46–27.14)	25.47 (17.73–39.05) *	33.37 (27.6–40.45) *	27.25 (19.97–33.94)	27.96 (23.5–34.55)
PUFA (gr)	15.37	11.86 (8.2–14.8)	11.37	9.91 (7.45–13.16)	11.45 (9.11–13.12) *	12.86 (10.6–18.5) *	9.82 (7.96–13.32)	12.25 (8.97–16.58)
S Fatty Acid (gr)	27.03	27.4 (19.56–31.46)	13.15	20.73 (14.76–25.06)	28.75 (21.41–32.75)	31.2 (24.21–37.17)	22.86 (18.07–30.09)	22.6 (17.88–28.78)

Trans Fats (gr)	0.51	0.7 (0.41–1.4)	1.47	0.54 (0.39–0.69)	0.65 (0.49–0.9)	0.8 (0.5–1.4)	0.82 (0.4–1.25)	0.66 (0.4–0.9)
Omega 3 (gr)	1.22	1.16 (0.8–2.24)	0.97	0.88 (0.6–1.23)	1.1 (0.67–1.55)	1.2 (0.86–2.2)	0.95 (0.72–1.53)	1.1 (0.74–1.85)
Omega 6 (gr)	11.3	9.55 (6.15–12.5)	7.16	6.7 (5.46–10.59)	8.5 (5.95–9.81) *	9.96 (7.58–14.3) *	8.04 (6.19–10.84)	9.27 (6.96–12.92)

Results are presented as medians (25th–75th Percentile). Symbol definitions: * $p \leq 0.05$ for comparisons between no organized sports participation and any organized sports participation among late-adolescent boys and # $p \leq 0.05$ for the corresponding comparisons among late-adolescent girls. Results are presented as medians (25th–75th Percentile). Symbol Definitions: * $p \leq 0.05$ for between late adolescent boys of MVPA ≥ 60 min/day and MVPA < 60 min/day. # $p \leq 0.05$ for the corresponding comparisons among late-adolescent girls. MVPA: Moderate-to-vigorous-intensity physical activity.

Table 4a,b present dietary intake according to adherence to WHO physical activity recommendations; detailed vitamin and mineral variables are provided in Supplementary Tables S5 and S6. Among late-adolescent boys, those achieving MVPA ≥ 60 min/day had higher protein, cholesterol, manganese, and zinc intake than those reporting MVPA < 60 min/day. Among late-adolescent girls, those achieving MVPA ≥ 60 min/day had higher intake of total energy, carbohydrates, fiber, starch, simple sugars, protein, thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, cobalamin, vitamin D, folate, copper, magnesium, and manganese than those reporting MVPA < 60 min/day. The larger number of significant differences among physically active girls may partly reflect higher total food intake rather than uniformly healthier dietary quality. Therefore, absolute intake results were interpreted together with nutrient-density analyses standardized per 1000 kcal.

Table 4. (a) Energy and macronutrient variables according to WHO physical activity recommendations in early and late adolescents by gender. (b) Carbohydrate subtypes and lipid-related variables according to WHO physical activity recommendations in early and late adolescents by gender.

(a)								
Early Adolescents (n = 57)					Late Adolescents (n = 167)			
Eating Habits	Boys (n = 32)		Girls (n = 25)		Boys (n = 97)		Girls (n = 70)	
	MVPA < 60 min/day (n = 2)	MVPA ≥ 60 min/day (n = 30)	MVPA < 60 min/day (n = 4)	MVPA ≥ 60 min/day (n = 21)	MVPA < 60 min/day (n = 14)	MVPA ≥ 60 min/day (n = 83)	MVPA < 60 min/day (n = 32)	MVPA ≥ 60 min/day (n = 38)
Energy (Kcal)	2096.04	1871.73 (1664.64–2155.3)	1662.57 (1341.97–1954.18)	1628.17 (1410.87–1738.17)	2072.69 (1679.27–2236.95)	2184.2 (1715.4–2542.36)	1593.14 (1313.45–1805.48) #	1794.65 (1633.09–2027.37) #
CHO (gr)	236.09	217.34 (185.72–236.89)	183.66 (147.69–249.56)	164.48 (151.31–196.12)	215.4 (141.25–260.47)	220.3 (176.52–262.36)	165.08 (129.05–196.29) #	204.09 (165.78–229.02) #
Fat (gr)	96.01	77.83 (63.18–88.29)	69.65 (57.93–75.72)	66.13 (52.33–78.83)	90.1 (75.73–107.15)	88.0 (71.86–110.06)	73.37 (60.86–83.55)	76.16 (69.35–87.26)
Protein (gr)	71.88	81.39 (69.07–101.42)	67.49 (57.43–76.38)	66.96 (53.17–91.44)	80.67 (68.68–99.57) *	101.69 (76.9–129.24) *	69.69 (50.06–79.9) #	76.24 (65.47–89.96) #
CHO (%)	0.43	0.46 (0.43–0.48)	0.44 (0.43–0.5)	0.45 (0.37–0.48)	0.42 (0.31–0.48)	0.41 (0.37–0.46)	0.42 (0.37–0.46)	0.44 (0.39–0.48)
Fat (%)	0.42	0.36	0.38	0.36	0.4	0.38	0.4	0.38

		(0.33–0.39)	(0.33–0.39)	(0.3–0.39)	(0.34–0.5)	(0.34–0.42)	(0.37–0.44)	(0.34–0.4)
Protein (%)	0.13	0.17 (0.16–0.18)	0.16 (0.15–0.17)	0.17 (0.14–0.2)	0.16 (0.14–0.21)	0.18 (0.15–0.22)	0.15 (0.13–0.19)	0.16 (0.14–0.19)
(b)								
Early Adolescents (n = 57)					Late Adolescents (n = 167)			
Eating Habits	Boys (n = 32)		Girls (n = 25)		Boys (n = 97)		Girls (n = 70)	
	MVPA < 60 min/day (n = 2)	MVPA ≥ 60 min/day (n = 30)	MVPA < 60 min/day (n = 4)	MVPA ≥ 60 min/day (n = 21)	MVPA < 60 min/day (n = 14)	MVPA ≥ 60 min/day (n = 83)	MVPA < 60 min/day (n = 32)	MVPA ≥ 60 min/day (n = 38)
Starch (gr)	101.44	89.31 (71.53–114.28)	65.81 (40.62–96.82)	72.89 (39.51–82.2)	74.57 (48.6–96.37)	91.4 (67.07–114.69)	63.48 (46.15–82.64) #	82.55 (67.35–105.98) #
Fiber (gr)	19.91	17.49 (12.97–24.26)	20.21 (18.14–22.83)	16.28 (12.14–22.05)	20.89 (11.76–28.01)	18.2 (13.4–26.4)	12.88 (10.17–18.92) #	20.4 (15.11–23.12) #
Sugars (gr)	60.99	54.4 (43.38–78.57)	68.13 (52.38–69.02)	51.56 (47.9–74.03)	50.78 (33.9–61.15)	61.5 (44.2–83.3)	48.81 (35.97–62.75)	59.7 (33.09–71.85)
Simple sugars (gr)	215.85	194.5 (168.03–218.34)	161.38 (126.85–227.92)	147.27 (135.58–180.31)	188.48 (130.9–210.2)	195.9 (155.79–243.68)	147.13 (119.73–183.96) #	180.01 (145.85–210.25) #
Chol (mg)	227.79	270.38 (109.13–399.45)	135.28 (30.01–152.61)	217.55 (117.88–376.69)	232.0 (166.13–368.64) *	350.42 (235.4–459.5) *	197.71 (144.42–239.35)	209.11 (154.62–292.81)
MUFA (gr)	21.64	24.67 (18.86–32.85)	25.68 (8.05–30.96)	22.42 (14.23–26.54)	34.09 (21.57–40.2)	31.51 (25.85–40.24)	27.25 (20.04–33.5)	27.96 (23.63–35.6)
PUFA (gr)	20.48	11.86 (8.08–14.81)	12.47 (10.83–12.99)	8.63 (7.29–12.92)	13.7 (11.11–17.04)	12.6 (9.85–18.2)	9.52 (8.06–13.65)	12.36 (9.2–15.31)
S Fatty Acid (gr)	38	27.06 (19.3–29.65)	17.11 (4.32–23.96)	21.48 (14.91–25.82)	30.01 (24.34–34.5)	29.83 (23.9–37.17)	21.28 (18.02–30.27)	23.4 (17.96–29.16)
Trans Fats (gr)	1.8	0.65 (0.38–1.13)	0.59 (0.3–1.88)	0.57 (0.42–0.74)	0.6 (0.49–1.25)	0.79 (0.5–1.4)	0.68 (0.4–1.21)	0.67 (0.4–1)
Omega 3 (gr)	2.15	1.13 (0.79–2.06)	0.99 (0.85–1.28)	0.8 (0.59–1.22)	1.43 (0.45–1.86)	1.1 (0.84–2.06)	0.95 (0.73–1.58)	1.1 (0.72–1.65)
Omega 6 (gr)	17.74	9.24 (5.96–12.25)	10.12 (4.92–10.88)	6.63 (5.24–10.63)	9.13 (5.92–11.67)	9.61 (7.56–13.18)	7.83 (6.16–11.86)	9.27 (7.26–12.2)

Results are presented as medians (25th–75th Percentile). Symbol Definitions: * $p \leq 0.05$ for between late adolescent boys of MVPA ≥ 60 min/day and MVPA < 60 min/day. # $p \leq 0.05$ for the corresponding comparisons among late-adolescent girls. MVPA: Moderate-to-vigorous-intensity physical activity. Results are presented as medians (25th–75th Percentile). Symbol Definitions: * $p \leq 0.05$ for between late adolescent boys of MVPA ≥ 60 min/day and MVPA < 60 min/day. # $p \leq 0.05$ for the corresponding comparisons among late-adolescent girls. MVPA: Moderate-to-vigorous-intensity physical activity.

In Table 5a,b, nutrient intake expressed per 1000 kcal is compared between early and late adolescence among students with no exercise participation and those with any level of exercise participation; detailed vitamin and mineral variables are provided in Supplementary Tables S7 and S8. The analysis is presented for the total sample and separately by gender. This comparison aims to clarify differences in nutritional characteristics among these groups, based on the standardized assumption of a 1000 kcal daily intake, thereby

allowing a more meaningful comparison of nutrient density. The energy-standardized analyses were used to distinguish differences in nutrient density from differences primarily driven by higher total food intake; therefore, the interpretation emphasizes the most relevant energy-adjusted findings rather than all individual nutrient comparisons. The smaller number of statistically significant findings after energy standardization suggests that many differences observed in absolute nutrient intake were likely driven by higher total energy intake rather than by major differences in nutrient density. This point is emphasized in the interpretation of the dietary results.

Table 5. (a) Macronutrient variables per 1000 kcal compared to organized sports participation in early and late adolescents by gender. (b) Carbohydrate subtypes and lipid-related variables per 1000 kcal compared to organized sports participation in early and late adolescents by gender.

(a)								
Early Adolescents (n = 57)					Late Adolescents (n = 167)			
Boys (n = 32)			Girls (n = 25)		Boys (n = 97)		Girls (n = 70)	
Eating Habits	No Exercise (n = 1)	Any Exercise (n = 31)	No Exercise (n = 2)	Any Exercise (n = 23)	No Exercise (n = 14)	Any Exercise (n = 83)	No Exercise (n = 30)	Any Exercise (n = 40)
CHO (gr/1000 Kcal)	118.58	116 (107.08–120.94)	122.63	111.77 (95.79–118.96)	109.74 (98.28–131.13)	103.72 (91.64–116.21)	106.34 (93.53–117.09)	110.12 (99.37–121.61)
Fat (gr/1000 Kcal)	40.85	41.12 (37.31–43.56)	39.25	40.91 (34.05–44.58)	40.3 (35.73–48.17)	43.76 (39.36–47.87)	45.06 (41.06–49.1)	42.42 (39.3–45.35)
Protein (gr/1000 Kcal)	39.5	43.18 (39.98–46.73)	39.03	42.56 (37.3–52.36)	41.36 (36.33–51.73)	46.24 (39.77–56.08)	39.53 (33.84–47.89)	42.55 (37.39–48.7)
(b)								
Early Adolescents (n = 57)					Late Adolescents (n = 167)			
Boys (n = 32)			Girls (n = 25)		Boys (n = 97)		Girls (n = 70)	
Eating Habits	No Exercise (n = 1)	Any Exercise (n = 31)	No Exercise (n = 2)	Any Exercise (n = 23)	No Exercise (n = 14)	Any Exercise (n = 83)	No Exercise (n = 30)	Any Exercise (n = 40)
Starch (gr/1000 Kcal)	25.8	51.65 (38.99–61.84)	49.3	37.37 (25.14–51.37)	44.72 (34.62–55.36)	41.24 (29.56–51.16)	41.71 (27.27–49.74)	45.16 (37.78–53.28)
Fiber (gr/1000 kcal)	10.72	9.71 (7.7–12.74)	11.37	10.84 (9.33–12.69)	12.6 (6.77–13.87)	8.4 (6.44–12.09)	9.16 (6.59–13.45)	10.51 (7.81–12.08)
Sugars (gr/1000 Kcal)	38.11	31.41 (23.19–34.85)	36.06	37.09 (27.04–44.83)	26.61 (19.94–39.65)	28.82 (21.41–35.74)	30.47 (23.36–35.98)	33.89 (23.47–38.05)
Simple sugars (gr/1000 Kcal)	106.47	103.06 (95.19–111.95)	110.41	99.34 (86.07–107.77)	99.09 (89.18–110.78)	96.12 (83.13–104.63)	96.79 (84.24–110.2)	99.9 (88.11–110.45)
Chol (mg/1000 Kcal)	137.15	121.47 (70.39–178.15)	42.47	142.82 (77.37–178.99)	132.81 (85.03–166.06)	164.08 (121.25–215.22)	130.94 (86.02–150.96)	122.21 (90.21–168.54)

MUFA (gr/1000 Kcal)	15.16	12.14 (9.29–16.15)	9.69	14.79 (9.12–18.14)	13.13 (10.42–18.56)	15.26 (12.65–19.18)	17 (13.21–21.64)	15.5 (13.55–18.51)
PUFA (gr/1000 Kcal)	7.5	6.26 (4.48–7.82)	6.04	5.94 (4.85–8.26)	5.85 (4.99–6.88)	6.53 (4.99–7.97)	6.44 (4.72–7.97)	7.06 (5.34–8.7)
S Fatty Acid (gr/1000 kcal)	13.2	13.1 (12.06–15.87)	7.33	12.76 (10.93–14.75)	14.67 (13.03–16.76)	14.38 (12.73–16.1)	14.23 (12.31–17.02)	13.76 (11.36–14.78)
Trans Fat (gr/1000 kcal)	0.25	0.36 (0.26–0.65)	0.75	0.29 (0.27–0.47)	0.33 (0.28–0.44)	0.36 (0.22–0.58)	0.43 (0.27–0.76)	0.35 (0.24–0.5)
Omega 3 (gr/1000 kcal)	0.59	0.66 (0.42–1.04)	0.51	0.57 (0.47–0.83)	0.58 (0.25–0.78)	0.55 (0.4–0.9)	0.6 (0.43–0.89)	0.63 (0.43–0.98)
Omega 6 (gr/1000 kcal)	5.52	5.04 (3.56–5.73)	3.91	4.7 (3.47–6.46)	4.3 (3.56–5.2)	5.01 (3.65–6.02)	4.9 (3.62–7.16)	5.48 (4.16–6.81)

Results are presented as medians (25th–75th Percentile).

The analysis showed that, in late adolescence, inactive boys consumed higher amounts of vitamin B1 (thiamine) and sodium, whereas active boys showed a higher intake of zinc. On the other hand, active girls had higher intakes of vitamin B6 (pyridoxine) and vitamin B12 (cobalamin) compared with inactive girls.

Table 6a,b present nutrient intake per 1000 kcal according to adherence to the WHO physical activity recommendations; detailed vitamin and mineral variables are provided in Supplementary Tables S9 and S10. Because the number of non-exercising participants in early adolescence was small, comparisons in this subgroup should be interpreted cautiously. Among late-adolescent girls, those reporting MVPA < 60 min/day had higher intake of total fat and saturated fatty acids per 1000 kcal than those reporting MVPA ≥ 60 min/day. Conversely, late-adolescent girls meeting the MVPA recommendation had higher intake of fiber, pyridoxine (vitamin B6), and cobalamin (vitamin B12) per 1000 kcal. No significant differences were observed among boys. Comparisons involving very small cells should therefore be regarded as descriptive rather than definitive inferential results. Overall, the interpretation of Tables 3–6 was condensed to highlight the main clinically meaningful dietary patterns, while detailed values are presented for completeness and transparency.

Table 6. (a) Macronutrient variables per 1000 kcal according to WHO physical activity recommendations in early and late adolescents by gender. (b) Carbohydrate subtypes and lipid-related variables per 1000 kcal according to WHO physical activity recommendations in early and late adolescents by gender.

(a)								
Early Adolescents (n = 57)					Late Adolescent (n = 167)			
Boys (n = 32)		Girls (n = 25)			Boys (n = 97)		Girls (n = 70)	
Eating Habits	MVPA < 60 min/day (n = 2)	MVPA ≥ 60 min/day (n = 30)	MVPA < 60 min/day (n = 4)	MVPA ≥ 60 min/day (n = 21)	MVPA < 60 min/day (n = 14)	MVPA ≥ 60 min/day (n = 83)	MVPA < 60 min/day (n = 32)	MVPA ≥ 60 min/day (n = 38)
CHO (gr/1000 Kcal)	109.89	116.22 (107.5– 120.43)	112.27 (108.17– 127.29)	113.55 (92.64– 120.03)	105 (79.05–122.25)	104.75 (93.29– 116.7)	106.34 (94.01– 115.94)	112.12 (99.15– 122.04)

Fat (gr/1000 Kcal)	46.78	40.98 (37.3–43.47)	43.02 (36.95–44.3)	40.61 (33.68– 44.05)	44.51 (38.72–55.72)	43.01 (38.53–47.66)	45.06 (41.62–49.35) #	42.42 (38.35–45.27) #
Protein (gr/1000 Kcal)	34.84	43.41 (40.19–46.85)	40.82 (38.98– 42.81)	42.56 (35.98– 52.43)	41.36 (36.1–52.75)	46.24 (39.77–55.99)	39.64 (34.07– 47.77)	41.81 (36.96– 49.35)
(b)								
Early Adolescents (n = 57)					Late Adolescent (n = 167)			
Boys (n = 32)		Girls (n = 25)		Boys (n = 97)		Girls (n = 70)		
Eating Habits	MVPA < 60 min/day (n = 2)	MVPA ≥ 60 min/day (n = 30)	MVPA < 60 min/day (n = 4)	MVPA ≥ 60 min/day (n = 21)	MVPA < 60 min/day (n = 14)	MVPA ≥ 60 min/day (n = 83)	MVPA < 60 min/day (n = 32)	MVPA ≥ 60 min/day (n = 38)
Starch (gr/1000 Kcal)	50.47	51.59 (38.69– 59.23)	39.49 (27.94– 52.96)	40.85 (26.1–51.84)	36.78 (23.35–54.24)	42.85 (33.61–52.02)	42.9 (26.98–49.53)	44.46 (37.45–55.73)
Fiber (gr/1000 kcal)	9.55	10.21 (7.5–12.82)	12.32 (10.08–15.7)	10.81 (8.55–12.63)	11.7 (6.52–12.95)	8.46 (6.52–12.1)	8.08 (6.61–12.07) #	10.63 (8.22–12.55) #
Sugars (gr/1000 Kcal)	26.69	31.67 (23.31–35.45)	37.79 (34.49–43.25)	36.72 (26.38–44.93)	25.37 (19.94–31.56)	28.88 (21.41–36.13)	31.44 (23.78–36.15)	32.82 (21.64–38.23)
Simple sugars (gr/1000 Kcal)	100.18	103.33 (95.63–111.95)	96.92 (94.5–116.13)	100.16 (82.37–108.79)	92.42 (70.69–106.36)	96.58 (85.67–105.9)	96.79 (84.72–108.52)	101.15 (87.53–111.42)
Chol (mg/1000 Kcal)	112.76	125.06 (70.39–178.29)	81.1 (19.43–111.24)	143.66 (90.55–192.16)	132.81 (76.59–188.55)	154.76 (121.25–214.25)	130.94 (87.83–151.4)	117.32 (87.48–170.86)
MUFA (gr/1000 Kcal)	10.7	12.38 (10.18–16.36)	18.01 (5.59–18.26)	14.51 (8.32–16.64)	16.96 (10.99–22.53)	14.82 (12.32–18.99)	17.13 (13.46–21.71)	15.81 (12.99–18.99)
PUFA (gr/1000 Kcal)	10.42	6.33 (4.48–7.81)	7.75 (5.58–9.48)	5.71 (4.79–7.58)	7.21 (5.71–8.07)	6.21 (4.88–7.72)	6.44 (4.87–8.59)	7.01 (5.26–8.2)
S Fatty Acid (gr/1000 kcal)	18.21	13.04 (11.99–15.53)	12.01 (3.11–13.89)	12.76 (11.03–14.81)	14.84 (13.8–17.66)	14.3 (12.73–16.09)	14.76 (12.49–16.51) #	13.31 (11.27–14.32) #
Trans Fat (gr/1000 kcal)	0.86	0.36 (0.22–0.57)	0.39 (0.19–0.96)	0.29 (0.27–0.48)	0.32 (0.27–0.54)	0.36 (0.22–0.58)	0.42 (0.27–0.64)	0.35 (0.25–0.5)
Omega 3 (gr/1000 kcal)	1.09	0.66 (0.41–0.94)	0.59 (0.45–0.94)	0.55 (0.44–0.77)	0.69 (0.22–1.14)	0.54 (0.4–0.84)	0.6 (0.43–0.98)	0.63 (0.39–0.96)
Omega 6 (gr/1000 kcal)	9.03	5.07 (3.53–5.7)	6.51 (2.78–7.39)	4.31 (3.41–5.87)	5.02 (3.65–5.77)	4.85 (3.59–5.96)	5.13 (3.6–7.54)	5.4 (4.17–6.6)

Results are presented as medians (25th–75th Percentile). Symbol Definitions: # $p \leq 0.05$ for the corresponding comparisons among late-adolescent girls. MVPA: moderate-to-vigorous-intensity physical activity. Results are presented as medians (25th–75th Percentile). Symbol Definitions: # $p \leq 0.05$ for the corresponding comparisons among late-adolescent girls. MVPA: moderate-to-vigorous-intensity physical activity.

4. Discussion

This study examined anthropometric, body-composition, physical-activity, and dietary characteristics among Greek adolescents. The findings indicate associations by sex, age-defined adolescent stage, and sports engagement. Overall, boys had higher fat-free mass and lower fat-mass percentage than girls, and adolescents who participated in organized exercise reported different nutrient-intake patterns than their inactive peers. These findings should not be interpreted as evidence of causal effects. The observed sex differ-

ences in body composition are consistent with established patterns of pubertal development. Boys had greater height, body weight, and FFM than girls, whereas girls had a higher fat-mass percentage. In late adolescence, boys had a median FFM of 32.6 kg compared with 22.1 kg among girls, while fat-mass percentage was higher in girls than boys. These differences are consistent with reports by Wells et al. [45] and Abreu and Kaiser [46] and are largely explained by puberty-related hormonal changes: testosterone promotes lean-mass accretion in boys, whereas estrogens contribute to greater fat deposition and sex-specific fat distribution in girls [47,48]. Similar sex-based differences have also been reported in adolescent populations by Galán-López et al. [49] and other studies [50–53].

Consistent with the previous literature, boys in the present study were more likely than girls to participate in sports and structured physical activity. Eime et al. [54] and other studies [55,56] have shown that boys tend to participate in sports more frequently from childhood, often with greater parental encouragement. Comparable sex differences in activity patterns have also been reported among Spanish adolescents [57]. These differences may partly reflect variation in motor competence, particularly object-control skills such as ball handling, in which boys often outperform girls [58,59]. Because motor competence predicts both current and future sports participation [59], these developmental differences may contribute to lower activity levels among girls.

In addition to biological maturation, physical activity patterns and dietary intake may also contribute to the observed sex differences in body composition. Greater participation in structured sports may be associated with higher fat-free mass through greater training exposure and energy requirements, while differences in food choices, total energy intake, and nutrient density may further influence body-composition characteristics. However, these interpretations remain exploratory because the cross-sectional design does not allow causal inference.

Findings from Mediterranean adolescent populations provide useful context for the present results. Studies conducted in Spanish adolescents have reported associations between adherence to the Mediterranean diet, physical fitness, and body-composition characteristics, and have also described sex-related differences in physical activity and dietary patterns [49,57]. In line with this literature, the present findings suggest that organized sports participation may be linked not only to activity behavior but also to broader health-related lifestyle patterns among adolescents in a Mediterranean setting. However, because the present study was cross-sectional, these comparisons should be interpreted as descriptive and hypothesis-generating rather than causal.

In this sample, 76.8% of adolescents reported meeting the WHO recommendation of at least 60 min of MVPA per day, including 87.6% of boys and 62.1% of girls. These proportions are higher than those reported by Sánchez et al. [60], who found that 45% of adolescents met the recommendation, and higher than estimates from studies using objective measures, in which approximately 30% of adolescents achieve recommended activity levels [61]. Differences in measurement method may partly explain this discrepancy, as self-reported physical activity can overestimate true activity levels. Previous studies also identify television viewing and other screen-based activities as common sedentary behaviors among adolescents [62,63], while international evidence suggests that a large proportion of adolescents fail to meet recommended physical activity levels [64]. Therefore, the high percentage of participants meeting the WHO recommendation may partly reflect overestimation inherent in self-reported questionnaires and should not be interpreted as an objectively measured prevalence estimate. Thus, the reported adherence to WHO physical activity recommendations should be interpreted as self-reported adherence rather than objectively measured compliance. The high prevalence may reflect regional sampling characteristics, the school-based recruitment context, and possible selection of adolescents with greater interest in sports or health-related behaviors.

The findings support previous evidence linking adiposity, lean mass, and physical activity with fitness and health outcomes. Higher adiposity has been inversely associated with physical fitness [29], whereas fat-free mass [65] and MVPA [66] are positively associated with fitness. In line with previous work [67], sedentary time may not remain independently associated with fitness after accounting for age, body composition, and MVPA. In the present cross-sectional study, these variables should be interpreted as correlates of adolescent fitness and health-related characteristics rather than as causal determinants.

Macronutrient intake in the present cohort was broadly consistent with dietary-reference recommendations [7], although several concerns were identified. Energy intake in late adolescence was lower than reference values, with late-adolescent boys consuming a median of 2193 kcal/day compared with an EFSA reference of 2717 kcal/day for high physical activity. Fiber intake was generally adequate, and carbohydrate contribution to energy intake was within the recommended range. Protein intake met recommended levels, and total fat intake was within the recommended energy range; however, saturated fat intake slightly exceeded recommended thresholds.

Potential under-reporting of energy intake should also be considered, as under-reporting is common in adolescent dietary surveys and may be influenced by recall difficulties, social desirability, body-weight concerns, or omission of snacks and beverages. Therefore, the lower reported energy intake should be interpreted cautiously and may not necessarily reflect true habitual energy intake.

Despite generally adequate macronutrient intake, possible micronutrient inadequacies were observed. Intakes of thiamine (vitamin B1), riboflavin (vitamin B2), folate, vitamin K, and vitamin D appeared adequate in several subgroups, whereas lower potential intakes were observed for pantothenic acid (vitamin B5), pyridoxine (vitamin B6), cobalamin (vitamin B12), vitamin A, vitamin C, and vitamin E. Regarding minerals, iron and phosphorus intakes were generally sufficient, whereas calcium, copper, magnesium, manganese, and zinc showed possible inadequacies. These findings suggest that even when total macronutrient intake appears acceptable, micronutrient intake may remain suboptimal during adolescence. Accordingly, the micronutrient findings should be interpreted cautiously, as a three-day recording period may not adequately reflect usual micronutrient intake or day-to-day variation in micronutrient consumption.

Because the present study assessed dietary intake only and did not include biochemical biomarkers, reported micronutrient inadequacies should not be interpreted as confirmed nutritional deficiencies. Instead, they indicate potential dietary inadequacy and should be confirmed in future studies using biomarkers of nutritional status and longer-term dietary assessment.

These results are consistent with the HELENA study, which identified insufficient status or intake of several micronutrients among European adolescents, including vitamin D, pyridoxal phosphate, folate, beta-carotene, and vitamin E [68]. Together, these findings reinforce the importance of monitoring micronutrient intake and dietary quality during adolescence. Puberty is a period of accelerated growth and increased requirements for vitamins and minerals [69–71]. HELENA findings further indicated that many European adolescents consumed fewer than recommended servings of fruits and vegetables while exceeding recommended intake of meat, fats, and sweets [68,72]. Low intakes of vitamin D and folate, inadequate intake of polyunsaturated fatty acids, and excessive saturated fat intake have also been reported [68,72].

Social and environmental factors strongly shape adolescent dietary behaviors [73,74]. These influences may contribute to higher consumption of sweets, sugar, and fat and lower intake of vegetables and fruits [75–79].

Parental dietary habits are particularly important. Adolescents' perceived parental intake of fruits, vegetables, and fats has been associated with their own dietary behaviors

[80–83]. Adolescents whose parents follow lower-fat dietary patterns may be more likely to adopt similar practices [82,83]. Across diverse adolescent populations, nutrients of concern frequently include folate [84,85], calcium [76,86,87], vitamin D [88,89], and iron [90].

However, parental dietary practices, parental education, and household food availability were not directly assessed in the present study. Therefore, parental influence is discussed only as a contextual explanation based on the previous literature and should not be interpreted as an observed determinant in this sample.

CDC data also indicate that only a small proportion of U.S. adolescents aged 12–19 years meet recommendations for total fat and saturated fat intake [61,63]. In addition, fewer than one quarter of high-school students consume at least five daily servings of fruits and vegetables [91]. These findings underscore that dietary inadequacy during adolescence is a global public health issue.

Adolescence is also a critical period for the development of sports skills and lifelong health behaviors, because rapid changes in body composition and hormone levels influence both physical performance and nutritional needs [92]. Among adolescent athletes, insufficient intake of iron, vitamin D, and calcium is common, and sports dietitians often recommend increased attention to these nutrients [92]. Evidence also suggests that both macro- and micronutrient intake among adolescent athletes may fall below recommendations [93,94]. Similar patterns of low energy intake have been reported in other adolescent groups [95], consistent with the underconsumption observed in the present study.

It should also be emphasized that the present sample consisted of adolescents reporting organized sports participation, not necessarily competitive adolescent athletes. Therefore, comparisons with athlete-specific studies are informative but should be made cautiously, as training volume, competitive level, and nutritional supervision may differ substantially.

The observed sex-specific associations between organized sports participation and nutrient intake may have several possible explanations. Boys and girls differed in the type and prevalence of organized sports participation, with boys more frequently reporting team-sport participation and girls more frequently reporting gym-based or individual activities. These differences may be associated with variation in training volume, energy requirements, food choices, body-composition characteristics, and social influences from peers, families, coaches, and sports environments. Higher absolute nutrient intake among adolescents participating in organized sports may partly reflect greater total energy intake, whereas the energy-standardized analyses suggest that some differences may also relate to dietary quality. These explanations remain speculative, as the study design does not allow assessment of causal mechanisms.

Overall, the key interpretation is that organized sports participation was associated with differences in dietary patterns and nutrient density rather than merely higher absolute nutrient intake. The attenuation of several differences after standardization per 1000 kcal suggests that part of the observed variation was explained by higher total food intake, while the remaining energy-adjusted differences may reflect aspects of dietary quality.

4.1. Practical Implications

The findings may have practical implications for school-based health promotion, adolescent nutrition education, and organized sports settings. Schools, families, coaches, and health professionals could use organized sports participation as an opportunity to reinforce nutritionally adequate dietary patterns, while also paying attention to adolescents who do not participate in organized sports and to girls who reported lower participation and lower adherence to physical activity recommendations. Nutrition education should emphasize adequate intake of nutrients relevant to adolescent growth and sports participation, including protein, fiber, vitamin D, calcium, magnesium, iron, and zinc. These im-

plications should be interpreted cautiously because the study was cross-sectional and based on self-reported dietary and physical activity measures.

4.2. Limitations and Future Directions

This study has several limitations. First, the cross-sectional design precludes causal inference regarding associations among body composition, physical activity, dietary intake, and related outcomes. Accordingly, all findings should be interpreted as associations rather than effects. Second, self-reported physical activity and dietary data may be affected by recall bias and social desirability bias, potentially leading to overestimation of physical activity or underreporting of energy intake. Third, pubertal status was not clinically assessed through Tanner staging or other biological maturation indicators; therefore, the age-defined adolescent-stage categories may not fully reflect biological maturation and may have introduced some misclassification. Although the sample included adolescents from several areas of Attica, the findings may not be generalizable to all Greek adolescents or to adolescents in other countries. In addition, selection bias cannot be excluded, because participation depended on returning signed parental consent and adolescent assent forms. Adolescents or families with greater interest in health, nutrition, or sports may have been more likely to participate, which may limit the representativeness and generalizability of the findings. This limitation is particularly relevant given the relatively high proportion of adolescents reporting achievement of the WHO physical activity recommendation. Future studies should include objective physical activity measures, such as accelerometers, to validate self-reported activity levels. Statistical comparisons based on such small cells have limited reliability and statistical power; therefore, these results should be interpreted with extreme caution and regarded as descriptive and hypothesis-generating. In addition, dietary intake was estimated using three-day food records. Although this method is recognized and included two non-consecutive weekdays and one non-consecutive weekend day, the short recording period may not fully capture habitual intake, seasonal variation, or day-to-day variability, particularly for micronutrients. Body composition was assessed using BIA, which is less precise than reference techniques such as DXA and may be influenced by hydration status, recent food or fluid intake, recent physical activity, and other measurement conditions. Therefore, body-composition estimates should be interpreted cautiously. Additional methodological limitations include: the absence of systematic data on training frequency, duration, weekly training volume, and competitive level; the lack of direct hydration assessment before BIA measurements; possible inaccuracies when matching Greek foods or local recipes in the nutrition-analysis database; and the absence of formal correction for multiple testing, which increases the possibility of type I error in the nutrient-specific subgroup analyses.

Future studies should use longitudinal and interventional designs with objective measures of physical activity, detailed dietary assessment, and biological markers of nutritional status. School- and family-based interventions targeting micronutrient adequacy, physical inactivity, and excess adiposity should also be evaluated to support healthier developmental trajectories during adolescence.

5. Conclusions

In this sample of Greek adolescents, body-composition characteristics, physical-activity patterns, and dietary intake differed according to sex, age-defined adolescent stage, and organized sports participation. Organized sports participation was associated with differences in body-composition characteristics and selected macro- and micronutrient intakes, particularly among late adolescents; however, these findings should be interpreted cautiously because of the cross-sectional design and the use of self-reported physical activity and dietary data.

The observed body-composition differences should therefore be interpreted as cross-sectional associations and not as evidence that organized sports participation caused more favorable body-composition characteristics.

Although macronutrient intake was generally within recommended ranges, potential inadequacies in selected micronutrients were observed. These results should be considered exploratory and hypothesis-generating, and they do not establish causal relationships between organized sports participation, dietary intake, and body composition.

Future longitudinal and intervention studies using objective physical activity measures, more detailed dietary assessment, and biomarkers of nutritional status are needed to clarify the direction, magnitude, and clinical relevance of these associations in adolescents.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/adolescents6040052/s1>; Table S1: Questionnaires Used for the Present Study; Table S2: Student Questionnaire; Table S3: Vitamin Intake Variables Compared to Organized Sports Participation in Early and Late Adolescents by Gender. Table S4: Mineral and Trace-element Intake Variables Compared to Organized Sports Participation in Early and Late Adolescents by Gender; Table S5: Vitamin Intake Variables According to Who Physical Activity Recommendations in Early and Late Adolescents by Gender; Table S6: Mineral and Trace-element Intake Variables According to Who Physical Activity Recommendations in Early and Late Adolescents by Gender; Tables S7: Vitamin Intake Variables Per 1000 Kcal Compared to Organized Sports Participation in Early and Late Adolescents by Gender.; Table S8: Mineral and Trace-element Intake Variables Per 1000 Kcal Compared to Organized Sports Participation in Early and Late Adolescents by Gender.; Table S9: Vitamin Intake Variables Per 1000 Kcal According to Who Physical Activity Recommendations in Early and Late Adolescents by Gender.; Tables S10: Mineral and Trace-element Intake Variables Per 1000 Kcal According to Who Physical Activity Recommendations in Early and Late Adolescents by Gender.

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