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Comparison of physical performance and body composition between students participating and not participating in high school sports competitions

André Bonadias Gadelha[a] | Arthur de Godoy Gonçalves[b] | Diogo Leles Burmester[c] | Yasmin Bezerra Pacheco[a] | Maurilio Tiradentes Dutra[ab]

[a]Federal Institute of Education, Science, and Technology of Brasília (IFB), Brasília, Brazil.
[b]Faculty of Physical Education, University of Brasília (UnB), Brasília, Brazil.
[c]Faculty of Education and Health Sciences, University Center of Brasília (UniCEUB), Brasília, Brazil.

Abstract Adolescence is a crucial stage of human development, characterized by significant physical and motor changes. Physical activity and sports play an essential role in supporting these processes, contributing to the development of a healthy body. However, the participation of high-school students in institutional sports events and its influence on body composition and physical performance remains to be better understood. This study aimed to compare physical performance and body composition parameters of students who do and do not participate in school sports competitions in a federal public school. Adolescents from 15 to 18 years old (52 boys, 70 girls) participated in this cross-sectional study. Body composition was assessed by a tetrapolar bioelectrical impedance device. Muscle handgrip strength, power, velocity, agility, and flexibility were also assessed. Female participants in sports competition presented lower fat mass (30.8 ± 7.2 % vs. 37.5 ± 7.4%, p<0.05) and higher fat free mass (28.0 ± 2.5% vs. 25.6 ± 2.4%, p<0.05) compared to the non-participating ones, with no differences in physical performance. Male participants in sports presented higher handgrip strength (90.5 ± 12.6 kgf vs. 78.7 ± 18.0 kgf, p<0.05) and improved agility performance (6.3 ± 0.6 s vs. 6.9 ± .0.6 s, p<0.05) compared to the non-participating ones, with no differences in body composition. Participation in school sports games is linked to better body composition in girls, while greater strength and agility in boys, suggesting that sports practice may be a determining factor for the development of physical capacities in adolescents. These findings reinforce the importance of educational policies that encourage sports participation as a strategy for promoting health during adolescence.

Keywords: adolescence, health, strength, muscle, fat

1. Introduction

Adolescence is a crucial stage of human development, characterized by significant physical and motor changes (WHO Guidelines on Physical Activity and Sedentary Behaviour, 2020). Thus, regular physical activity plays an essential role in supporting these processes, contributing to the development of a healthy and functional body throughout life (Dumith et al., 2021; WHO Guidelines on Physical Activity and Sedentary Behaviour, 2020). However, studies indicate negative changes in physical activity levels and body composition among school-aged youth, particularly during high school (Antoniassi et al., 2024)

Factors such as increased screen time and rising obesity indicators in adolescence have been widely investigated (Pelegrini et al., 2021). In Brazil, around 70% of adolescents exhibit sedentary behavior characterized by excessive screen time, defined as more than two hours per day spent on activities such as watching television, using computers, smartphones, or playing video games (Antoniassi et al., 2024). Additionally, nowadays approximately 25% of Brazilian youth are overweight or obese (Pelegrini et al., 2021).

Physical activity is a key tool in managing these conditions. However, according to the World Health Organization, most adolescents fail to meet the recommended minimum of 60 minutes of daily moderate-to-vigorous physical activity (WHO Guidelines on Physical Activity and Sedentary Behaviour, 2020). This lack of physical activity harms young people's health and greatly increases their risk of developing chronic diseases like obesity, type 2 diabetes, and hypertension as they age (Costa et al., 2017). Participation in sports during childhood and adolescence is not only safe but also linked to positive health outcomes, including greater muscle strength, enhanced cardiorespiratory fitness, and improved body composition, offering potential lifelong benefits (Alves et al., 2005; Alves & Alves, 2019; Aquino & Santos, 2024; Furtado et al., 2023; Gomes et al., 2017; Gomes et al., 2022).

The availability and promotion of sports activities in primary and secondary education institutions, particularly in high schools, can positively impact the immediate and long-term health of this population by reducing sedentary behavior and improving body composition (Cesarino et al., 2023; Furtado et al., 2023). Participation in sports events can offer additional benefits for school-aged youth, particularly in terms of retention and sustained engagement in physical activity (Possamai et al., 2024). Recently, Possamai et al. (2024) indicated that basketball athletes who began training in youth categories, such as under-12, were more likely to remain involved in the sport into adulthood. Furthermore, a recent observational study found that individuals who participated in sports during adolescence reported better self-perceived health in young adulthood (ages 23–28) compared to those who did not engaged in sports activities (Kokandakar et al., 2024).

Although participation in sports events during youth strengthens engagement in physical activity in adulthood, there remains a gap in the literature regarding the involvement of public high-school students in institutional sports events and its relationship with body composition and physical performance. Therefore, this study aims to compare the physical performance and body composition of students who participate in school sports competitions with those who do not in a public high school in the Federal District, Brazil.

2. Materials and Methods

2.1. Sample characteristics

The sample consisted by students enrolled in the high-school and technical education programs at the Instituto Federal de Brasília (IFB), Estrutural Campus, aged between 15 and 18 years (52 boys and 70 girls). Participants were recruited following the dissemination of the research through posters displayed on campus and invitations sent via institutional e-mail. Of note, the campus has approximately 250 regularly enrolled students.

2.2. Anthropometry, strength, and muscle power

Body mass was measured with participants wearing light clothing and barefoot, using a portable digital scale with a capacity of 150 kg (Omron HBF 514). Height was assessed using a portable stadiometer (Avanutri®). Body mass index (BMI) was calculated by dividing body mass by the square of heigth (kg/m²). So, body composition assessment, including body fat percentage, muscle mass percentage, and visceral adiposity index, was conducted using a tetrapolar bioelectrical impedance analysis (BIA) device (OMRON HBF-514, OMRON Healthcare Inc., Lake Forest, IL).

Muscle strength was assessed using a hydraulic handgrip dynamometer (SAEHAN™). Each participant performed three trials of five seconds of maximum isometric contraction, with a 30-second rest interval. The highest value recorded among the trials was considered for analysis. The sum of the grip strength of both hands was reported as the total handgrip strength (HGS).

Muscle power, upper and lower limbs, were assessed using the medicine ball throw test and the horizontal jump test, following the protocol and guidelines of the Sport Brazil Project (Projeto Esporte Brasil, PROESP-BR) from the Federal University of Rio Grande do Sul (available at: https://www.ufrgs.br/proesp/bat-teste-forca-explosiva-de-membros-superiores.php).

2.3. Agility and speed

The Square Test was used to assess agility, with results recorded in seconds based on the time taken by the subject to complete the course, which involves changes in direction following an "X" pattern marked by cones. The test was conducted according to the protocol and guidelines of the PROESP-BR. The 20-meter sprint test was used to assess students' speed. The result was recorded in seconds, based on the time taken by the participant to cover the 20-meter distance at maximum running speed. The test was conducted following the guidelines of the PROESP-BR protocol.

2.4. Flexibility

The sit-and-reach test was employed to assess flexibility. The procedures for test and performance classification have been previously described by protocols and guidelines (Ribeiro et al., 2010).

2.5. Statistics and ethics

Normality of data was assessed by the Shapiro-Wilk test. Participants were allocated into two groups ("athletes" and "non-athletes"). The term "athlete" was used to refer to students who had participated in sports competitions within the institution’s school games (i.e. called JIF) during the two years preceding the study.

Non-parametric distribution variables were compared using the Mann-Whitney U test, while parametric distribution variables were analyzed using the Student’s t-Test for independent samples. Data were presented as mean ± standard deviation, as well as median and interquartile range (25th, 50th, and 75th percentiles). Statistical analyses were performed using JAMOVI software, version 2.3.28, with the significance level set at $P < 0.05$.

All experiments were conducted in accordance with the Declaration of Helsinki and the study protocol was previously approved by the Institutional Review Board (CEUB 6.698.670).

3. Results

The distribution of volunteers by sex was 56% female and 44% male, with no significant difference between groups (X^2 = 1.8; P = 0.180). The proportion of non-athlete volunteers (69.6%) was significantly higher when compared to athletes (30.4%). This difference was also observed within the sex subdivisions, with 17.6% of females and 12.8% of males classified as athletes, while 38.4% of females and 31.2% of males were classified as non-athletes (X^2 = 21.1; P < 0.001). Four variables exhibited a non-parametric distribution among females: age, BMI, visceral adiposity index (VAI), and agility (P < 0.05). Among males, five variables followed a non-parametric distribution: age, BMI, body fat percentage, lean mass, and VAI (P < 0.005). All other variables exhibited a parametric distribution (P ≥ 0.05) for both sexes. Table 1 presents the comparison of descriptive and dependent variables among female participants.

It was observed that athletes had higher values for age (P < 0.001) and lean mass (P = 0.003) compared to non-athletes. However, variables related to body adiposity, such as body fat percentage and VAI, were significantly lower in the athlete's group (P ≤ 0.01; Table 1).

Table 1 Comparison of descriptive and dependent variables considering female participants.

					Percentiles				
	IFBSG	n	Mean	± SD	25th	50th	75th	P	
Age (years)	Yes	22	17.6	0.7	17.4	17.5	17.7	<0.001	#
	No	48	16.5	1.1	15.5	16.3	17.4		
Height (cm)	Yes	21	161.9	6.9	157.0	162.3	166.5	0.665	
	No	18	161.0	6.3	155.8	159.3	165.4		
Body mass (kg)	Yes	21	57.7	12.2	49.2	55.3	64.1	0.104	
	No	18	63.6	9.3	59.1	63.5	70.0		
Body mass index (kg/m²)	Yes	21	22.4	4.2	19.3	21.2	25.0	0.081	#
	No	18	24.6	4.2	22.5	24.1	27.3		
Fat (%)	Yes	21	30.8	7.2	24.4	30.3	34.2	0.008	
	No	18	37.5	7.4	33.4	37.9	43.1		
Fat-free mass (%)	Yes	21	28.0	2.5	26.1	28.8	30.1	0.003	
	No	18	25.6	2.4	23.5	26.0	26.9		
Visceral adiposity index (AU)	Yes	21	3.1	1.2	2.0	3.0	4.0	0.013	#
	No	18	4.2	1.3	4.0	4.0	4.8		
Total handgrip strength (kg)	Yes	22	53.2	10.8	50.0	52.0	56.8	0.483	
	No	45	51.4	9.7	44.0	52.0	59.0		
Hamstring flexibility (cm)	Yes	15	35.7	9.5	30.0	37.2	40.5	0.289	
	No	13	32.1	7.9	27.5	33.0	35.0		
Seated medicine ball throw (m)	Yes	8	3.9	0.8	3.3	3.8	4.3	0.357	
	No	7	3.6	0.5	3.3	3.4	4.1		
Horizontal jump (m)	Yes	19	156.3	27.2	143.0	152.0	180.5	0.105	
	No	14	141.1	23.9	121.9	137.4	158.4		
Agility (s)	Yes	19	7.1	0.9	6.4	6.8	7.5	0.161	#
	No	14	7.4	0.7	6.9	7.5	7.9		
Running (20m)	Yes	19	4.5	0.6	4.2	4.3	4.8	0.706	
	No	14	4.4	0.5	4.1	4.3	4.9		

Note: SD: Standard Deviation. AU: Arbitrary unit. IFBSG: IFB school games. # Variable with a non-parametric distribution; comparison using the Mann-Whitney U test.

Figure 1 illustrates the comparison between athletes and non-athletes (all females), considering the variables with significant differences (P < 0.05). Notably, body composition variables related to adiposity exhibited higher values in non-athlete volunteers compared to athletes. Conversely, an inverse pattern was observed for age and muscle mass (Figure 1).

Comparisons between the descriptive and dependent variables of male participants is presented in Table 2. Athletes exhibited higher values for age and strength when compared to non-athletes (P < 0.01; Table 2). Furthermore, the athletes were more agile (P = 0.006; Table 2).

Figure 2 illustrates the comparison between athletes and non-athletes (all males), considering variables with significant differences (P < 0.05). Age and handgrip strength were higher in athletes when compared to non-athletes (P < 0.01; Figure 2). Additionally, athlete volunteers demonstrated greater agility compared to non-athletes (P = 0.006; Figure 2).

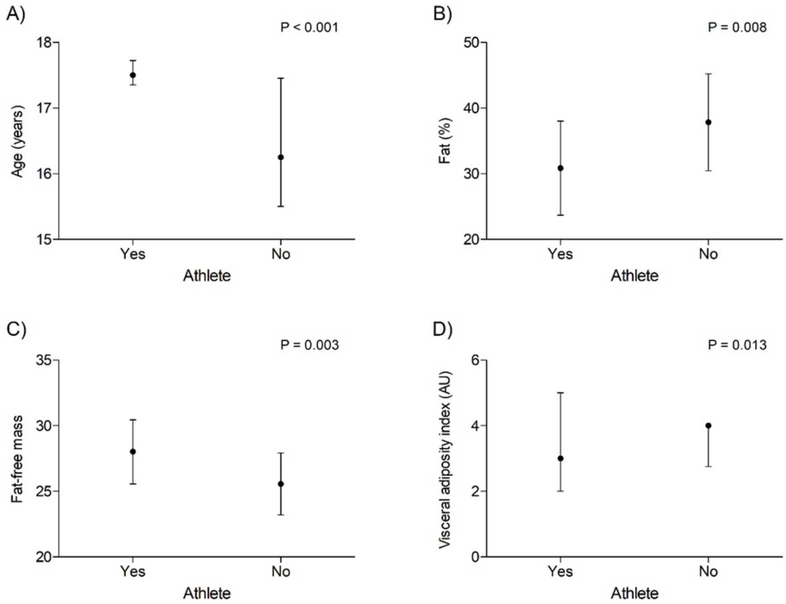

Figure 1 Comparison between athletes and non-athletes (all females) considering age, body fat, fat-free mass, and visceral adiposity index. Age (A) and visceral adiposity index (D) were compared using the Mann-Whitney U test and are presented as the median and interquartile range. Fat (B) and fat-free mass (C) were compared using the Student's t-test and are presented as the mean and standard deviation. UA: Arbitrary Unit.

Table 2 Comparison of descriptive and dependent variables considering only male participants.

					Percentiles				
	IFBSG	n	Mean	± SD	25th	50th	75th	P	
Age (years)	Yes	16	17.8	0.7	17.3	17.8	18.2	0.004	#
	No	39	16.5	1.4	15.3	15.8	17.8		
Height (cm)	Yes	15	174.4	7.7	171.5	172.6	179.3	0.784	
	No	16	173.7	5.6	172.0	173.6	176.8		
Body mass (kg)	Yes	15	64.4	7.9	57.2	64.7	71.5	0.287	
	No	16	68.4	12.2	60.5	67.3	74.1		
Body mass index (kg/m^2)	Yes	15	21.1	2.1	19.5	20.9	22.0	0.489	#
	No	16	22.2	3.7	20.2	20.8	23.0		
Fat (%)	Yes	15	13.3	5.7	10.1	11.3	16.8	0.453	#
	No	16	16.7	10.2	10.8	13.3	19.5		
Fat-free mass (%)	Yes	14	44.2	3.1	41.4	45.3	46.7	0.560	#
	No	16	42.5	6.3	40.7	44.6	45.9		
Visceral adiposity index (AU)	Yes	14	3.4	1.8	2.0	2.0	4.0	0.625	#
	No	16	4.0	2.5	2.0	2.0	5.0		
Total hand grip strength (kg)	Yes	15	90.5	12.6	81.0	91.0	97.0	0.025	
	No	38	78.7	18.0	65.3	77.0	89.3		
Hamstring flexibility (cm)	Yes	14	28.0	7.2	26.0	29.0	32.8	0.732	
	No	12	26.8	9.9	20.5	23.0	36.6		
Seated medicine ball throw (m)	Yes	5	6.0	1.3	4.9	6.3	6.6	0.332	
	No	5	5.3	0.8	4.8	5.5	6.0		
Horizontal jump (cm)	Yes	15	217.2	31.3	203.5	225.0	230.6	0.173	
	No	13	197.1	44.1	184.0	195.0	214.0		
Agility (s)	Yes	15	6.3	0.6	5.9	6.2	6.7	0.006	
	No	13	6.9	0.6	6.6	6.6	7.3		
Running (20m)	Yes	15	3.6	0.3	3.4	3.5	3.8	0.158	
	No	13	3.8	0.4	3.6	3.8	4.0		

Note: SD: Standard Deviation. AU: Arbitrary unit. IFBSG: IFB school games. # Variable with a non-parametric distribution; comparison using the Mann-Whitney U test.

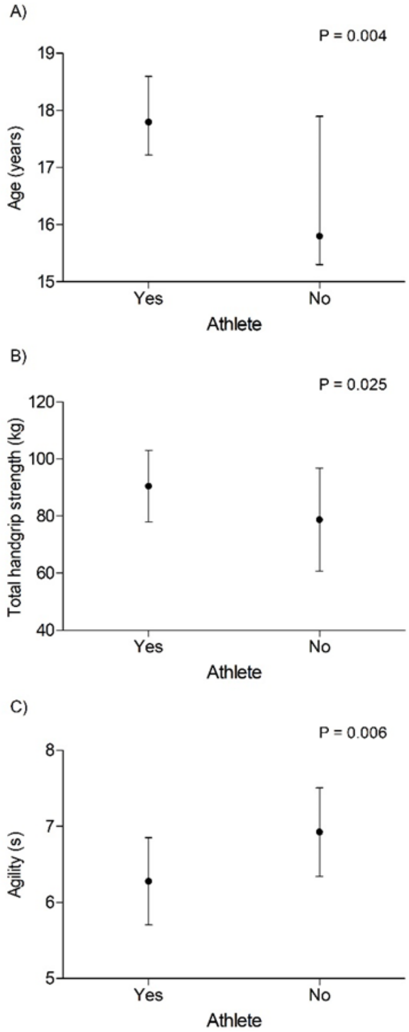

Figure 2 Comparison between athletes and non-athletes (all males) considering age, handgrip strength, and agility. The variable Age (A) was compared using the Mann-Whitney U test and is presented as the median and interquartile range. Both Handgrip Strength (B) and Agility (C) were compared using the Student's t-test and are presented as the mean and standard deviation.

4. Discussion

The present study sought to compare the physical performance and body composition of students who do and do not participate in school sports competitions in a public school in the Federal District, Brazil. It was observed that female athletes exhibited better body composition indicators when compared to non-athletes, with higher fat-free mass values, while lower body fat percentages and visceral adiposity index. Regarding male participants, athletes demonstrated superior results for total handgrip strength and agility when compared to non-athletes.

The lower body fat percentages and visceral adiposity index observed in female athletes in the present study represent favorable factors for body composition, considering that fat accumulation in the center of the body is associated with adverse health-related outcomes, particularly in the context of cardiometabolic health (Costa et al., 2017). The increasing prevalence of obesity among adolescents has been widely linked to sedentary behavior, characterized by excessive screen time and reduced physical activity levels (Antoniassi et al., 2024; Pelegrini et al., 2021; WHO Guidelines on Physical Activity and Sedentary Behaviour, 2020). In general, boys tend to have higher physical activity scores compared to girls, indicating a greater level of activity (Benítez-Porres et al., 2016). Additionally, female adolescents tend to accumulate a higher amount of body fat and show lower adherence to sports participation than boys (Campos et al., 2021), making them more susceptible to the development of metabolic diseases (Carvalho et al., 2025; Pelegrini et al., 2021). Previous studies have also highlighted the importance of sports participation in weight control among female adolescents (Aquino & Santos, 2024; Furtado et al., 2023), corroborating the findings of the present study.

Although no differences in body composition were observed among male participants, athletes demonstrated superior handgrip strength when compared to non-athletes. Handgrip strength is a relevant indicator of physical fitness, as it is associated with better health conditions throughout life (Gomes et al., 2017). A recent study conducted with adolescents indicated that higher handgrip strength values are correlated with better motor performance and lower risks of metabolic syndromes (Gomes et al., 2022). The athletes in the present study also demonstrated greater agility, reinforcing the positive influence of sports participation on motor development. This superiority reflects an enhanced ability to perform quickly and coordinately tasks, a fundamental skill that can be improved for performance in various sports disciplines (Alves et al., 2005).

The findings related to body composition and muscle strength variables, specifically body fat percentage and handgrip strength, partially align with the cutoff points proposed in the literature for adolescents of the same age group (Bim et al., 2021; Sena et al., 2022). The cutoffs for body fat percentage in adolescents aged 16 to 18 years, considering the 50th percentile obtained through bioelectrical impedance analysis, were established at 29.1% for females and 27.9% for males (Sena et al., 2022).

In the present study, the mean body fat percentage among females was 33.9%, slightly above the aforementioned cutoff value, while males had an average of 15%, significantly below the reference value. Lower body fat levels are associated with a reduced risk of cardiometabolic diseases and improved physical performance (Pelegrini et al., 2021). This finding may be related to the fact that males tend to be more physically active than females, a difference potentially influenced by sociocultural factors that can impact sports participation patterns and, consequently, body composition (Benítez-Porres et al., 2016).

Regarding handgrip strength, the values obtained were compared with the cutoffs proposed by Bim et al. (2021) for 17-year-old Brazilian adolescents, with the 50th percentile for total handgrip strength established at 78.3 kg for males and 51.2 kg for females. In the present study, the mean total handgrip strength was 82.1 kg for males, exceeding the reference value, while girls had a mean of 52 kg, showing no difference from the cutoff value suggested in the literature. This result suggests that the boys assessed exhibit better muscle strength development, a factor associated with health benefits and physical fitness throughout life.

Altogether, the results of the present study have a relevant practical impact regarding adolescents' health, as well as adult health, once sedentary behavior and the absence of sports practice during adolescence may lead to chronic diseases (Costa et al., 2017) and elevate health related costs to public systems. In this sense, school public policies should incorporate physical education and sports classes at all school levels, with a minimum frequency to support optimal development during childhood and adolescence. The Brazilian Pediatric Society, for example, recommends that children and adolescents from 6 to 19 years old should accumulate at least 60 minutes of moderate to vigorous physical activities daily (Barros et al. 2017). School physical education and sport can play an essential role in this regard.

The present study has several limitations. It is important to highlight that the research was conducted in a federal public school located in a peripheral region of Brasília, limiting the generalizability of the findings to other educational and socioeconomic contexts. Also, participation in IFB school games is voluntary, suggesting that students who choose to compete may have a greater affinity for sports activities and, consequently, better physical conditions. In this study, due to logistical scheduling constraints and attendance issues for the tests, not all participants completed all assessments, as indicated in Tables 1 and 2, which may limit the statistical analysis. Another relevant factor is that athletes were significantly older than non-athletes, albeit with a small difference. It is well known that chronological age directly influences physical performance (Possamai et al., 2024), a phenomenon observed in youth categories across various sports. Furthermore, a recent systematic review pointed out that there is no consensus regarding the direct or inverse association between sexual maturation and physical activity (Campos et al., 2021).

5. Conclusions

Based on the findings of the present study, we concluded that participation in IFB school games was associated with better body composition indicators in female athletes, while greater strength and agility in male athletes, suggesting that sports practice may be a determining factor for the development of physical capacities in adolescents. Future studies may explore the influence of different sports modalities on body composition and physical fitness in young individuals, as well as investigate motivational factors for adherence to and retention in sports. These findings reinforce the importance of educational policies that encourage sports participation as a strategy for promoting health during adolescence.

Acknowledgment

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Ethical Considerations

All tests were conducted in accordance with the Declaration of Helsinki and the study protocol was previously approved by the Institutional Review Board (UniCEUB protocol number 6.698.670).

Conflict of Interest

The authors declare no conflict of interest.

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