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Relationship between anthropometric values and physical fitness in children and adolescents

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ABSTRACT

The aim of this study was to analyse the relationship between anthropometric variables and physical fitness in children and adolescents, assessing the impact of Body Mass Index (BMI), Waist to Hip Ratio (WHR) and Waist to Height Ratio (WHtR) on motor performance. This was a descriptive, cross-sectional study of 455 children and adolescents (92 girls and 363 boys) aged between 6 and 17, enrolled at the Sports Initiation Center (NIES) in Canaã dos Carajás-PA. Anthropometric measurements were taken and flexibility, strength, aerobic endurance, speed and agility tests were applied. The results indicated that a higher BMI was negatively correlated with aerobic endurance and positively associated with upper limb explosive strength and flexibility. WHR was negatively correlated with flexibility and lower limb explosive strength, especially among girls. WHtR had the most significant correlations, negatively impacting cardiorespiratory endurance and muscle strength, but showing a positive association with agility and speed. We conclude that body composition significantly influences physical fitness, highlighting the importance of monitoring anthropometric indicators in childhood and adolescence to promote health and motor performance.

Keywords: Sport health, Body composition, Physical education, Physical fitness, Anthropometry.

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INTRODUCTION

Assessing the factors that influence physical fitness in children and adolescents has been a subject of growing interest in the health and sports sciences. Body composition, expressed by anthropometric measures such as Body Mass Index (BMI), Waist to Hip Ratio (WHR) and Waist to Height Ratio (WHtR), has been widely studied in relation to different components of physical fitness, such as strength, flexibility, cardiorespiratory endurance and agility. Understanding these interactions is fundamental to formulating strategies aimed at promoting health and motor development in childhood and adolescence.

Several studies have shown that a higher BMI tends to be negatively associated with physical performance in children and adolescents. Dumith et al. (2010) and Dumith et al. (2012) point out that individuals with high BMI levels have lower cardiorespiratory fitness, which is reflected in poorer performance in aerobic endurance tests, such as the 6-minute run and the 20-meter shuttle test. In addition, Mendoza-Muñoz et al. (2020) and Petrovics et al. (2020) point out that the relationship between BMI and physical fitness can follow a U-shaped pattern, indicating that both underweight and overweight or obese children can present physical limitations. Lourenço et al. (2023) emphasize that WHR also plays an important role in physical fitness, being negatively associated with agility and speed in children and adolescents.

The relevance of this study lies in the need to better understand how different anthropometric indicators influence the physical fitness of children and adolescents, allowing for more effective interventions to prevent health problems such as obesity and a sedentary lifestyle. By identifying the correlations between body composition and physical performance, this study can support educational programs and public policies aimed at promoting physical activity and improving the quality of life of this population. The main objective of this study is to analyze the relationship between anthropometric values and physical fitness in children and adolescents.

METHOD AND MATERIALS

Research design

This study adopts a descriptive and cross-sectional methodological approach, which, according to Hochman et al. (2005), consists of collecting data at a single point in time, allowing the prevalence of certain characteristics to be analysed in a specific population. This type of study is widely used to assess associations between anthropometric variables and physical fitness, providing a comprehensive view of the physical condition of children and adolescents at a given time (Bastos; Duquia, 2007).

With regard to ethical issues, the research was conducted in accordance with the principles of the Declaration of Helsinki for studies with human beings and followed the guidelines of the National Health Council for research involving minors. Before data collection began, a meeting was held with the participants' parents and guardians to present the objectives of the research, its relevance and the methodological procedures. The research was previously approved by a Research Ethics Committee, ensuring compliance with all ethical guidelines for studies with children and adolescents.

Participants

The sample consisted of 455 children and adolescents, 92 girls and 363 boys aged between 6 and 17, living in Canaã dos Carajás - PA, and enrolled in the Sports Initiation Center (NIES), a social project offered by the Municipal Foundation for Culture, Sport and Leisure - FUNCEL. The NIES covers various sports, such as

futsal, society soccer, volleyball, basketball, karate, muay-thai, judo and jiu-jitsu, providing a suitable environment for analysing the relationship between anthropometric variables and physical fitness.

The inclusion criteria adopted were: to be a student regularly enrolled at NIES and attending classes regularly; to be in the stipulated age group (6 to 17 years); and to have the consent of those responsible to take part in the research. Students were excluded from the study if: they were absent at the time of the assessments; they reported pain or showed signs of injury during the tests, which could compromise the validity of the results; and they did not obtain the consent of their parents or guardians to take part.

Measures

To ensure accurate and reliable data collection, standardized instruments validated in scientific literature were used, following the protocols established by the Brazil Sports Project (PROESP-Br), as described by Reis Gaya et al. (2021). The anthropometric assessment included the measurement of body weight, measured using a digital scale accurate to 100g, and height, measured using a portable stadiometer, guaranteeing a reliable assessment of the participants' growth. Wingspan was measured using a tape measure fixed to the wall, while waist and hip circumferences were obtained using a flexible tape measure, following internationally standardized protocols.

Physical fitness was assessed using specific motor tests. Flexibility was measured using the sit and reach test, which assesses the range of movement of the posterior chain. The explosive strength of the lower limbs was determined by the horizontal jump, while the explosive strength of the upper limbs was measured by throwing a 2 kg medicine ball. Localized muscular endurance was assessed using the 1-minute sit-up test, and cardiorespiratory fitness was estimated using the 6-minute run test, a protocol widely used to assess the aerobic capacity of children and adolescents. Agility and speed were analysed using a rapid displacement test with a change in direction, allowing the response time and motor efficiency of the participants to be verified.

Procedure

Data collection took place in a controlled environment, within the NIES sports facilities, over a period of four weeks. Initially, meetings were organized with those responsible to present the objectives of the study and clarify any doubts. After this stage, the participants underwent an initial screening, in which their health conditions and eligibility to take part in the study were checked.

The assessments were carried out on two separate days, with a 48-hour interval between sessions to avoid excessive fatigue. On the first day, anthropometric measurements were taken, including weight, height, wingspan and body circumferences, following the PROESP-Br recommendations. Each measurement was taken three times and the average of the values obtained was taken for greater precision.

On the second day, the participants underwent the physical tests, which were carried out by a trained team made up of physical education professionals and trained volunteers. Before the tests, a standardized warm-up was carried out, consisting of joint mobility exercises and dynamic stretches. Each test was then explained and demonstrated in detail to ensure the correct execution of the movements. Participants were given a chance to familiarize themselves before the test was officially carried out, minimizing possible execution errors.

By adopting a rigorous and standardized methodology, this study ensures the validity and reliability of the data, providing relevant information for understanding the relationship between body composition and physical fitness in children and adolescents.

Statistical analysis

The results obtained were recorded manually on individual spreadsheets and then entered into a Microsoft Excel for Windows database and analysed using the R Studio software (v 4.1.1). For the statistical analysis, descriptive statistics were used, with measures of central tendency (mean) and dispersion (standard deviation), as well as minimum and maximum values, allowing for a detailed characterization of the sample. In addition, Spearman's test was used to identify associations between the physical fitness and anthropometric variables, considering the correlations as: weak (0.10-0.39); moderate (0.40-0.69); strong (0.70-0.89); and very strong (0.90-1.00), considering the *p*-value <.05 as significant.

RESULTS

The study sample consisted of 455 children and adolescents, 92 females (20%) and 363 males (80%), aged between 6 and 17 years. The median age was 12 years for females and 10 years for males (Table 1).

Table 1. Characterization of the sample.

Variables	Female (n = 92)			Male (n = 363)		
	Min.	Median	Max.	Min.	Median	Max.
Age (years)	6	12	17	6	10	17
Weight (kg)	17.7	45.9	82.4	17.5	37.3	101
Height (m)	1.11	1.54	1.68	1.11	1.44	1.83
Wingspan (cm)	1.09	1.59	1.87	1.10	1.45	1.99
Waist (cm)	0.48	0.65	0.89	0.50	0.62	0.96
Hip (cm)	0.59	0.86	1.14	0.51	0.76	1.13

The mean values of the anthropometric variables differed between the sexes. In females, the median weight was 45.9 kg, height was 1.54 m, wingspan was 1.59 m, waist circumference was 0.65 m and hip circumference was 0.86 m. In males, the median weight was 37.3 kg, height 1.44 m, wingspan 1.45 m, waist circumference 0.62 m and hip circumference 0.76 m (Table 1).

The statistical analysis showed associations between the anthropometric variables and the physical tests carried out by the participants. Among the girls, BMI was correlated with flexibility and upper limb explosive strength, while WHR was correlated with flexibility and lower limb explosive strength. WHtR, in turn, was associated with the 6-minute run, abdominal endurance and agility (Table 2).

In the male group, BMI was also related to flexibility and upper limb explosive strength. WHR was associated with different physical fitness parameters, including flexibility, upper limb explosive strength, speed and lower limb explosive strength. WHtR was correlated with the 6-minute run, abdominal endurance, speed, lower limb explosive strength and agility (Table 2).

The results show variations in the associations between the different anthropometric components and physical fitness in children and adolescents, highlighting distinctions between the sexes in the relationships identified.

Table 2. Associations between variables.

Variables	Female (n = 92)			Male (n = 363)		
	BMI	**WHR**	**WHtR**	**BMI**	**WHR**	**WHtR**
Flexibility (cm)	0.21*	-0.26*		0.12*	-0.12*	
Racing (6 min.)	-0.38*		-0.40*		-0.30**	-0.51**
Abdominal (1 min)		-0.41*			-0.22**	-0.28**
Explosive force MMSS	0.61**			0.53**	-0.36**	
Speed (seg)						
Explosive force MMII		-0.43*		0.16*	-0.33**	-0.30**
Agility (seg)			0.28*		0.26**	0.23**

*Note: *p < .05; **p < .00*

DISCUSSION

The aim of this study was to analyse the relationship between anthropometric values and physical fitness in children and adolescents, identifying how different body measurements influence motor performance. The main findings revealed significant correlations between BMI, WHR and WHtR with various components of physical fitness, with significant differences between the sexes.

The results showed that Body Mass Index (BMI) had both a positive and negative correlation with different physical fitness variables. In girls, a higher BMI was positively associated with flexibility (0.21)* and upper limb explosive strength (0.61)*, which suggests that, to a certain extent, a higher body mass can favour these physical abilities (Table 2). However, a negative correlation was also observed with the 6-minute run (-0.38), indicating an adverse impact on aerobic endurance. These findings corroborate the studies by Dumith et al. (2010, 2012), who point out that increased BMI tends to impair cardiorespiratory fitness due to the greater energy expenditure required for locomotion.

Similar patterns were found in the male group. BMI showed positive correlations with flexibility (0.12)* and upper limb explosive strength (0.53), but negative correlations with the 6-minute run (-0.30), reinforcing the fact that excess weight can impair aerobic endurance while favouring strength (Table 2). These results are also compatible with the literature, which points out that BMI can be a predictor of worse aerobic performance, but without necessarily compromising muscle strength (Mendoza-Muñoz et al., 2020; Petrovics et al., 2020).

Waist-to-hip ratio (WHR) showed negative correlations with various physical fitness components. In girls, a higher WHR was negatively associated with flexibility (-0.26)* and lower limb explosive strength (-0.43)*, suggesting that greater central adiposity can compromise lower limb mobility and power (Table 2). Studies such as those by Buchan et al. (2012) and Lourenço et al. (2023) show that the accumulation of fat in the abdominal region can limit joint mobility and impair performance in activities that require coordination and explosive strength.

In boys, WHR also showed negative associations, affecting flexibility (-0.12), upper limb explosive strength (-0.36), speed (-0.33)* and lower limb explosive strength (-0.30)** (Table 2). These findings reinforce the idea that body fat distribution, rather than total weight, can be a determining factor in motor performance, especially in activities that require rapid movement and muscle explosion.

Waist-to-height ratio (WHtR) showed the most significant correlations with physical fitness variables, especially in the male group. In boys, a higher WHtR was negatively associated with the 6-minute run (-0.51),

1-minute sit-ups (-0.28), speed (-0.30)** and lower limb explosive strength (-0.30)** (Table 2). These findings are compatible with studies such as those by Ortiz-Sanchez et al. (2022), which indicate that a greater accumulation of abdominal fat may be related to lower cardiorespiratory and muscular performance due to increased resistance to movement and structural overload.

However, a higher WHR was found to be positively correlated with agility (0.26)** and speed (0.23**)**, suggesting that, despite cardiorespiratory and muscular limitations, some individuals with a higher WHR may perform better in rapid change of direction tasks (Table 2). This relationship may be associated with individual biomechanical and structural factors but requires further investigation.

Limitations

Despite the relevant findings, some limitations should be considered. Firstly, this study was cross-sectional, which prevents the determination of causal relationships between anthropometric indicators and physical performance. Longitudinal studies could provide a more precise understanding of how these associations evolve over time.

In addition, the sample was made up of children and adolescents involved in a sports initiation program, which may represent a population with levels of physical activity above the average for the general population. This characteristic may influence the results, making them less representative of sedentary children and adolescents. Future studies should include more diverse samples to broaden the applicability of the findings.

Another point to consider is that BMI, despite being a widely used indicator, has limitations as it does not differentiate between muscle mass and body fat. The inclusion of more precise methods, such as bioimpedance or skinfold assessment, could provide a more detailed analysis of the participants' body composition and its real influence on physical fitness.

CONCLUSION

By analysing the relationship between anthropometric values and physical fitness in children and adolescents, this study confirmed that different anthropometric indicators have a significant influence on the physical performance of the participants, thus achieving the proposed objective.

The main findings showed that BMI was negatively correlated with aerobic endurance but was positively associated with upper limb explosive strength and flexibility. WHR was negatively correlated with flexibility and lower limb explosive strength, especially in females. WHtR showed the most significant negative correlations, negatively affecting the 6-minute run, abdominals and lower limb explosive strength, especially in males. However, positive associations were also observed between WHtR and agility, suggesting that its influence on physical performance may vary according to the activity analysed.

These findings reinforce the importance of monitoring body composition in childhood and adolescence, highlighting the need for strategies that promote the maintenance of an adequate weight and regular physical activity. Future studies, including longitudinal analyses and more precise body assessment methods, may contribute to a more in-depth understanding of the relationships between anthropometric variables and physical fitness throughout child and adolescent development.

SUPPORTING AGENCIES

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author.

INFORMED CONSENT STATEMENT

Written informed consent has been obtained from the participants and legal guardians to conduct and publish this study.

DATA AVAILABILITY STATEMENT

The data presented in this study are available on request from the corresponding author.

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