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RESEARCH ARTICLE **OPEN ACCESS**

Relationship Between Anthropometric Attributes and Physical Fitness Levels in Young Male Portuguese Futsal players

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Abstract:

Background: Futsal demands lower limb power, repeated sprint ability, and technical prowess. Furthermore, anthropometric characteristics have been shown to influence physical capacities and sports performance and, thus, should be assessed alongside physical fitness levels to maximize performance.

Methods: This study aimed to investigate the potential correlations between anthropometric characteristics and physical fitness levels among young Portuguese male futsal players and to compare these attributes across two distinct age groups. Twenty-one male athletes from two age groups (Under-18: N=14 - 16.1 ± 0.6 years old; Under-15: N=7 - 13.7 ± 0.6 years old) were recruited to take part in this investigation. Anthropometric characteristics [body weight, height, body mass index (BMI), waist and hip circumference, and waist-to-hip ratio] were assessed, and participants performed three performance tasks (20-meter sprint, vertical and horizontal jump).

Results: Statistically significant differences regarding body weight ($p=0.005$), height ($p=0.011$), and hip circumference ($p=0.036$) were observed between age groups (Under-18 and Under-15), but no differences were found regarding performance tasks (all $p\geq0.736$).

Conclusion: After analyzing the entire sample, BMI was found to be inversely correlated with horizontal ($r=-0.51$; $p=0.03$) and vertical ($r=-0.64$; $p<0.001$) jump performance, and waist-to-hip ratio was positively correlated with 20-meter sprint performance ($r=0.70$; $p<0.001$). These indicate a correlation between a higher BMI and waist-to-hip ratio with lower physical fitness levels.

Keywords: Futsal, Anthropometric characteristics, Sprinting, Jumping, Performance, Young athletes.

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1. INTRODUCTION

Futsal is a sport that exemplifies an intermittent activity, exhibiting a repeated oscillation between moments of heightened intensity (*e.g.*, sprinting, jumping, and attacking movements) and phases of lower intensity (*e.g.*, set-pieces and defensive movements) [1, 2]. This dichotomy requires adequate physiological and neuromuscular attributes, including endurance capability, repeated sprint ability, and lower-limb power [3, 4]. This composite spectrum of prerequisites underlines the

multifaceted requirements intrinsic to futsal, whose attributes encompass not solely technical ability, such as dribbling, finishing, or passing, but also demand an improvement in the physical attributes of the players to optimize athletic performance [1].

Proficiency in dynamic actions, such as sprinting and moving throughout the court, is essential to futsal performance. These can be influenced by a complex interplay of various factors such as biomechanics, physiology, and anthropometric characteristics [4-7], which collectively determine the ability of an athlete to rapidly accelerate, decelerate, and generate explosive power on the futsal court. In this complex interrelationship, body composition and anthropometric characteristics stand out as important contributors that may influence athletic performance [6, 9, 10]. Body composition, reflective of the proportionality between fat-free mass and fat mass, inherently modulates the power-to-weight ratio of an athlete, critically influencing their performance in jumping and sprinting tasks [11]. Furthermore, the interplay between these anthropometric attributes and the execution of dynamic actions is complex and crucial, as a higher body mass index (BMI) may exert both positive and negative influences on performance [11]. While it can be associated with enhanced force production due to increased body mass, it may also hinder agility and speed due to excess weight. For instance, Nikolaidis and colleagues [9] examined young basketball players. They observed that those who were overweight demonstrated inferior performance in running and jumping capabilities compared to their peers with a lower BMI. Conversely, Barbieri *et al*. [11] showed that preeminent sprinters exhibited elevated BMI levels, conceivably attributable to higher levels of fat-free mass, a critical determinant for strength and force production [12, 13]. Understanding the link between these anthropometric characteristics and futsal performance is crucial as it may provide insights for refining training programs to optimize these attributes, offering an advantage for athletes in executing fundamental dynamic actions and enhancing their overall performance in futsal.

While research into athletic performance has gathered considerable attention in the context of soccer, a smaller number of investigations exist within the domain of futsal [14-16], especially concerning young athletes [17, 18]. Futsal emerges as a highly competitive intermittent invasion team sport (based on the opposition between two teams, in which success depends on players and team action) [19, 20], characterized by the constant action of attacking and defending in a common space. It unfolds as a complex, often unpredictable, and highly dynamic sport. Therefore, there is a need for targeted research in young futsal players, as the distinct requirements of futsal, including the rapid transitions between high-intensity actions and the intricacies of spatial confinement, engender a unique athletic landscape [19-21]. The variation in gameplay dynamics and the physiological demands within futsal warrant specialized examination, especially among youth athletes who represent a crucial cohort in shaping the future of the sport.

Furthermore, several factors significantly change throughout adolescence due to maturation processes, such as performance levels and anthropometric characteristics [22]. For instance, increases in age tend to be accompanied by higher values for height and body mass [22], as well as higher values regarding strength and force production capacities [23]. While some research exists on the anthropometric characteristics and physical fitness levels of futsal players [3], studies specifically focusing on young athletes and their performance outcomes, such as sprinting and jumping abilities, remain limited. Moreover, given the varied stages of development during adolescence, it is crucial to evaluate anthropometric and performance measures across different age groups. This study seeks to address this gap in the literature by examining the potential influence of anthropometric characteristics on performance attributes associated with futsal, particularly in younger athletes, as well as potential differences between different age groups.

By elucidating the interplay between anthropometric attributes and physical fitness levels, as well as differences regarding age groups, this field of research has the potential to unravel important insights into the determinants of athletic proficiency in futsal. Such insights can provide a foundation for future research and guide targeted training interventions, promoting the optimization of the physiological capacities of the players and consequently elevating their overall performance capabilities on the court. Therefore, the main goal of this investigation was to explore whether anthropometric characteristics (waist-to-hip ratio and BMI) were correlated with three performance tasks (20-meter sprint and vertical and horizontal jump) in young Portuguese male futsal players. Moreover, this study aimed to compare the anthropometric characteristics and performance tasks between two age groups (Under-15 and Under-18).

2. METHODS

2.1. Participants

This investigation utilized a cross-sectional study design, with assessments conducted from June 1st to June 10th, 2022. This timeframe corresponded to the latter phase of the in-season period, specifically between the 40th and 41st weeks following the commencement of the season. A sample size calculation was conducted using the G*Power program (version 3.1.9.7) [24], and based on previous research investigating the association between BMI and sprinting performance ($r=0.60$; $p<0.001$) [25], a statistical power of 80% and a level of significance of 5%, it was estimated that a minimum of 19 participants would be required to observe a significant association between BMI and sprinting performance (for the whole sample). Considering a possible dropout, twenty-one young male futsal players from two distinct age groups were recruited to participate in this study. The first group consisted of seven athletes aged 13.7 ± 0.6 years (Under-15), while the second group included 14

individuals aged 16.1 ± 0.6 years (Under-18). These athletes adhered to a training regimen of three sessions per week, each lasting 90 minutes, resulting in a total of 270 minutes of weekly training. All participants were healthy and devoid of injuries or limitations that could influence the study outcomes (performance during physical tasks). Before data collection, written consent was obtained from the legal guardians of all participants and oral assent from the participants.

3. PROCEDURES

The research received approval from the University Ethics Committee (Approval code: P02-S09-27042022), and the study protocol adhered rigorously to the guidelines stipulated by the Declaration of Helsinki [26]. This study evaluated anthropometric characteristics and physical fitness levels through three performance tasks performed before a training session and after a standardized dynamic warm-up protocol consisting of jogging and dynamic drills (about 10 minutes). Before data collection, athletes were presented with comprehensive information about the study, and a familiarization session was conducted for each performance task. All participants were evaluated in a controlled environment (i.e., a quiet room at the university laboratory, without any external interference) and were asked to abstain from the consumption of caffeine and other stimulants in the 24 hours prior to data collection. Assessments were performed during the evenings with an environmental temperature of 20.4 degrees Celsius and relative humidity between 85% and 100% on all days.

3.1. Instruments

3.1.1. Anthropometry

Body weight and height were measured using a digital scale (SECA 761, Bacelar & Irmão Lda, Portugal) and a stadiometer (SECA 213, Bacelar & Irmão Lda, Portugal), respectively. These measurements were taken while participants were barefoot and wearing minimal clothing. Body weight and height were subsequently used to calculate BMI using the following formula:

$$BMI = BW/h^2$$

Where:

BMI (kg/m^2) = Body Mass Index

BW (kg) = Body weight

h (m)= Height

Waist and hip circumferences were measured following the guidelines set forth by the World Health Organization [27]. Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, while hip circumference was measured around the widest portion of the buttocks. These measurements were then utilized to calculate the waist-to-hip ratio (i.e., waist circumference divided by hip circumference), an indicator of cardiometabolic health.

3.1.2. Physical Fitness Levels

Assessments of jumping and sprinting proficiencies were undertaken through the utilization of tests embedded within the *FITescola®* test battery [28], a compilation of assessments is delineated below:

3.1.2.1. Horizontal and Vertical Jump

The horizontal and vertical jumps entailed athletes achieving their greatest distance in either the horizontal or vertical direction during a jump. Each participant was granted two attempts, and the most successful attempt was selected for the analyses outlined in this study. For the horizontal jump, a measuring tape was positioned on the floor, requiring athletes to execute a jump for maximal horizontal distance, with the option to leverage upper limb momentum. Conversely, during the vertical jump, participants positioned themselves with elevated arms to establish a baseline height measurement (from the floor to the highest point of their fingers). Subsequently, participants executed a countermovement jump, utilizing the necessary momentum. During this test, participants were holding a piece of chalk to mark the highest point achieved during the vertical jump. The difference between the initial baseline measurement and the attained jump height constituted the outcome of the vertical jump assessment.

3.1.2.2. 20-meter Sprint

The 20-meter sprint test assessed the time taken by athletes to complete an all-out unidirectional sprint. Each participant was allowed two attempts, with the best performance selected for the analyses presented in this study. Time measurements were obtained using a chronometer (HUAWEI Band 4 Pro).

3.2. Statistical Analysis

Data analysis was performed using SPSS software version 25 (IBM Corp., Armonk, New York). The Shapiro-Wilk test was used to assess the normality of the distribution of collected variables. Following confirmation of normal distribution, independent sample t-tests were employed to compare differences between the two age groups (Under-15 and Under-18). Subsequently, partial correlations, adjusted for age group, were conducted to examine associations between anthropometric characteristics (BMI and waist-to-hip ratio) and physical fitness performance tasks (vertical and horizontal jump and 20m sprint). Statistical significance was set at $p < 0.05$.

4. RESULTS

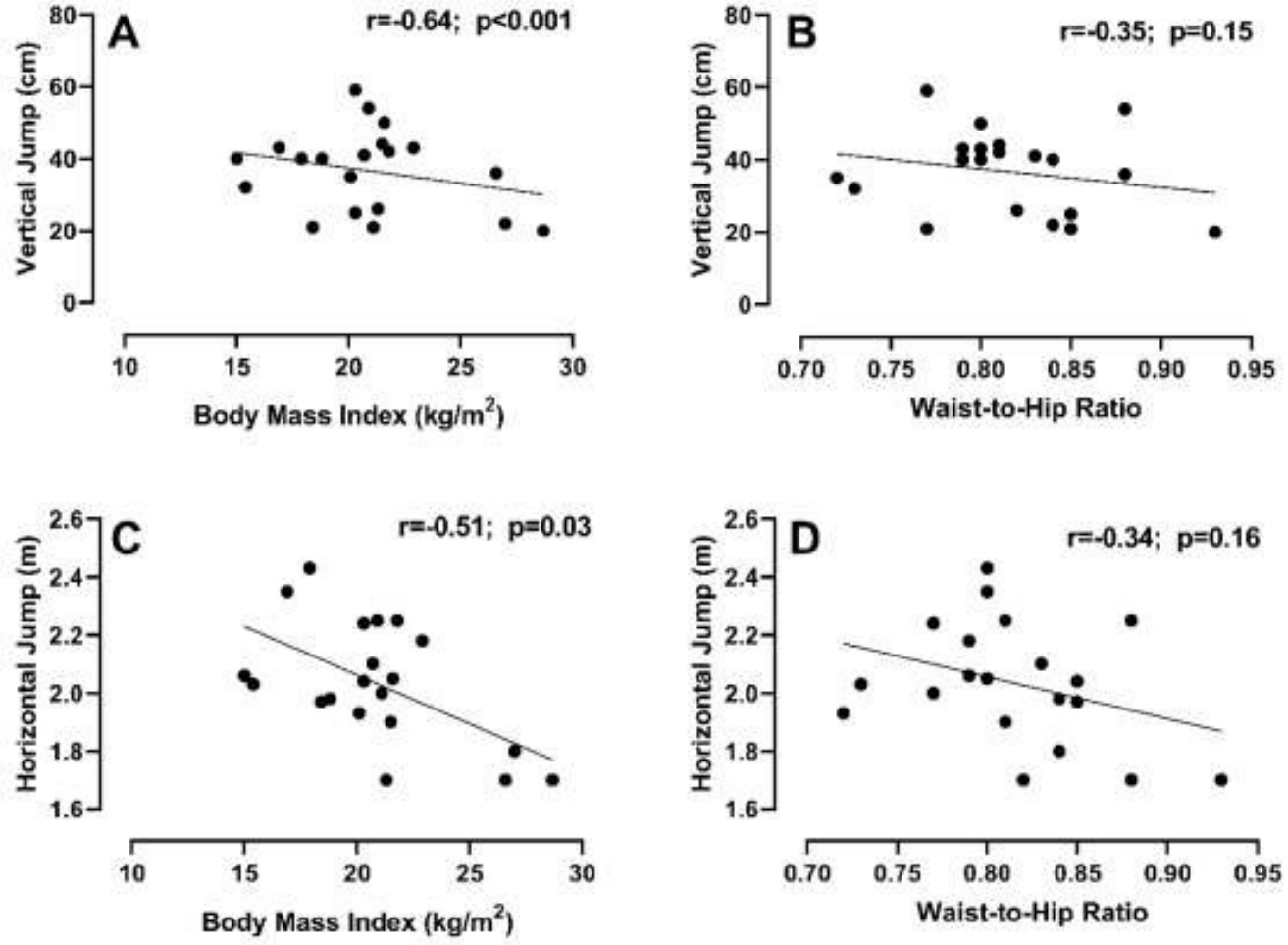
Descriptive characteristics encompassing the entire sample per age group, alongside inter-group differences, can be found in Table **1**. The variables that presented statistically significant differences between the two age groups were height, body weight, and hip circumference, in which older participants (Under-18) presented higher values. No differences were observed regarding physical fitness performance tasks between Under-15 and Under-18 athletes.

Table 1. Descriptive characteristics for the entire sample and by age group, as well as differences between the two age groups.

Age-Groups	Total (N=21)	Under-15 (N=14)	Under-18 (N=7)	p
Age	14.52 ± 1.29	13.71 ± 0.59	16.14 ± 0.64	0.005 *
Height (m)	1.70 ± 0.08	1.67 ± 0.08	1.77 ± 0.06	0.011 *
Body weight (kg)	60.90 ± 13.09	55.57 ± 10.12	71.57 ±12.26	0.005 *
BMI (kg/m^2)	20.80 ± 3.46	19.78 ± 3.08	22.84 ± 3.48	0.053
Waist C. (cm)	75.29 ± 10.37	71.86 ± 5.99	82.14±14.09	0.092
Hip C. (cm)	91.76 ± 8.61	88.57 ± 5.32	98.14 ±10.69	0.036 *
Waist-to-hip ratio	0.81 ± 0.05	0.80 ± 0.04	0.83 ± 0.06	0.210
Vertical jump (cm)	36.7 ± 11.35	37.15 ± 7.04	35.86 ± 17.54	0.815
Horizontal jump (m)	2.03 ± 0.20	2.04 ± 0.22	2.01 ± 0.20	0.747
20m sprint (s)	3.12 ± 0.45	3.14 ± 0.46	3.07 ± 0.48	0.736

Legend: BMI – Body mass index; C – Circumference. * - p<0.05 - Statistically significant differences between age groups.
All results were obtained during data treatment.

As can be observed from the data (Fig. 1), the waist-to-hip ratio exhibited a positive correlation with the 20-meter sprint, whereby athletes characterized by greater waist-to-hip ratios generally demonstrated prolonged times to complete the specified distance. Moreover, an inverse relationship was established between BMI and jumping performance, as individuals with elevated BMI values exhibited diminished vertical and horizontal distances during the conducted jump evaluations.



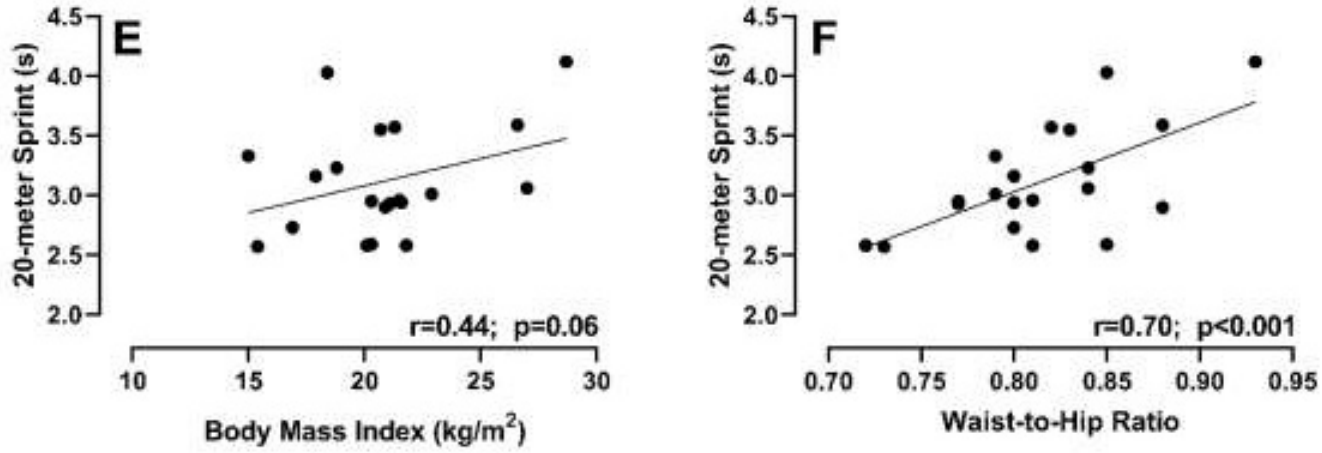


Fig. (1). Partial correlations between waist-to-hip ratio and body mass index with 20m sprint, horizontal, and vertical jump performance tests.
All results were obtained during data treatment.

5. DISCUSSION

This study aimed to explore whether anthropometric characteristics (waist-to-hip ratio and BMI) were correlated with three performance tasks (20-meter sprint and vertical and horizontal jump) in young male futsal players. Moreover, this investigation compared the anthropometric characteristics and performance tasks (sprinting and jumping abilities) between two age groups (Under-15 and Under-18). When assessing the entire sample, an elevated BMI and a higher waist-to-hip ratio were associated with less favorable outcomes in both sprinting and jumping performance assessments. Furthermore, it was observed that older individuals exhibited higher body weight, height, and waist and hip circumferences. However, there were no differences between age groups regarding the performance tasks.

Previous studies have consistently demonstrated the significant influence of anthropometric characteristics on sprinting and jumping abilities [6, 9]. For instance, Daugherty [6] observed that, in male and female adults, high levels of body fat should be avoided to maximize jumping performance. Additionally, Nikolaidis [9] observed that, in young basketball players, overweight players had the worst performance in running (both sprinting and endurance abilities) and jumping in U-12 and worse endurance in U-18 than normal-weight players. However, no differences were found in U-15 players. Therefore, while no study was previously conducted specifically in futsal players, these data suggest that these attributes, encompassing body composition and mass distribution, may play an important role in the biomechanical efficiency of an athlete during dynamic tasks like sprinting and jumping [9, 11]. Therefore, the observed associations between BMI and waist-to-hip ratio with performance outcomes in sprinting and jumping tasks in the present investigation can potentially be attributed to their impact on the body composition and biomechanics of an athlete. A higher BMI often (but not always) reflects an increased proportion of body fat [29], which can contribute to greater overall body mass. This, in turn, increases the requirements for force production during sprinting and jumping, potentially affecting performance [9, 11].

Furthermore, a higher waist-to-hip ratio typically implies a greater concentration of mass around the waist region, and it is associated with higher levels of visceral fat [30] and overall body fat mass [31], which can affect an athlete's ability to generate vertical and horizontal force [9, 11, 32]. As a result, athletes with elevated waist-to-hip ratios may experience challenges in achieving optimal sprinting and jumping performance [32]. These findings underscore the complex interplay between body composition, biomechanics, and physical performance, highlighting the importance of tailored training regimens to optimize these factors for futsal players.

Regarding the influence of age on performance, previous research has demonstrated that through adolescence, older athletes generally present higher scores [22, 23]. Notably, no significant differences were found regarding performance task outcomes between the two age groups in the present investigation, and age exhibited no association with performance task values. This result could be attributed to several factors. Firstly, the age range of the participants might have fallen within a relatively narrow window of maturation [33], with both younger and older athletes experiencing similar stages of physical development (specialized movement phase). Secondly, the quality and consistency of training and skill development could have played a role in minimizing age-related disparities. It is worth noting that while we observed no significant age-related differences, training history may have varied among individual participants, possibly influencing their performance outcomes. More-

over, given the sample size, the study may have had limited statistical power to detect subtle performance distinctions that could exist between age groups. Thus, although the current study did not reveal distinctions between age groups, it remains plausible that age holds significance as a contributing factor to performance, warranting further investigation.

While contributing valuable insights, this study is not devoid of certain pitfalls that require further consideration. Firstly, the exclusively male composition of the participant pool could limit the applicability of the results to the female futsal athlete demographic. Furthermore, the scope of the study encompassed a focused evaluation involving only three performance tasks, which may not encapsulate the full spectrum of physical abilities relevant to futsal. Moreover, the investigation primarily relied on BMI and circumferences as markers of anthropometric characteristics, omitting detailed measurements of body composition. Additionally, it is noteworthy to acknowledge the inherent variability in the developmental stages of the participants included in the study. Given the age range of the participants, spanning various stages of physical and physiological development, the findings regarding differences in anthropometric characteristics may reflect inherent differences in maturation levels. Future studies should expand the participant pool to encompass a more substantial cohort, including female futsal players and different age groups. This will facilitate a more holistic perspective on the multifaceted interactions between anthropometric characteristics and physical fitness abilities. In pursuit of a more comprehensive assessment, studies could incorporate an extended array of performance tasks, capturing a wider range of futsal-specific physical attributes. Exploring more intricate facets of body composition beyond BMI and circumferences, such as including measures like body fat percentage and skeletal muscle mass, could offer a nuanced understanding of the physiological underpinnings of performance disparities. By addressing these avenues, future studies have the potential to yield a more nuanced and detailed comprehension of the interrelations between anthropometric attributes and physical competence in the context of futsal. We also believe that future research should analyze these variables under different ecological conditions, at different times of the season, and even during games and training.

6. PRACTICAL APPLICATIONS

The findings of the present investigations highlight important considerations for coaches working with young futsal players. Our results underscore the relevance of assessing anthropometric characteristics, such as BMI and waist-to-hip ratio, in evaluating the physical fitness levels of young futsal players. While these measurements provide valuable insights into potential areas for further assessment or targeted interventions, it is important to note that this study did not directly measure body composition. Thus, coaches should exercise caution when inferring specific training recommendations solely based on anthropometric data. Further, coaches should prioritize holistic assessments and individualized training approaches that address the unique needs of each athlete.

Moreover, our findings suggest a potential relationship between higher BMI and waist-to-hip ratio and decreased sprinting and jumping performance. While this may indicate the importance of maintaining healthy body composition, particularly with regard to reducing body fat, caution is warranted in implementing weight loss interventions, especially in young individuals who may be at different stages of development. Therefore, any recommendations for weight management should be approached with careful consideration of the individual athlete's overall health and well-being.

CONCLUSION

This study identified age-related differences between Under-15 and Under-18 athletes in body measurements within the futsal context, highlighting the dynamic nature of these characteristics. Notably, physical fitness levels were similar across age groups, underscoring the multifaceted aspects of athletic development. Moreover, an inverse relationship between higher BMI and waist-to-hip ratio and decreased sprinting and jumping performance was observed. While these findings suggest the importance of maintaining healthy body composition, caution is warranted in prescribing training interventions solely based on anthropometric data. Nonetheless, these results provide foundational insights for further research and contribute to the understanding of futsal and similar sports.

ABBREVIATION

BMI	=	Body Mass Index

ETHICAL STATEMENT

Ethical approval for the investigation was granted by the University Ethics Committee (P02-S09-27/04/2022) and the study protocol adhered rigorously to the guidelines stipulated by the Declaration of Helsinki (General Assembly of the World, 2014).

CONSENT FOR PUBLICATION

Before data collection, written consent was obtained from the legal guardians of all participants and oral assent from the participants.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of the article is available in the Zenodo repository, under the doi 10.5281/zenodo.10910993.

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None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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