BODY COMPOSITION AND HANDGRIP STRENGTH RELATIONSHIP IN YOUNG FOOTBALL PLAYERS

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ORIGINAL SCIENTIFIC ARTICLE
DOI: 10.5937/ATAVPA25161U

***Abstract**: The aim of this study is to analyze the relationship between different body composition parameters and handgrip strength in football players aged 11 to 15 years. Handgrip strength was measured using a dynamometer, while body composition was assessed with three different devices: In Body, Omron, and Tanita. Body composition parameters, including skeletal muscle mass , body fat percentage, body mass index , and segmental muscle distribution, may significantly impact strength performance. The results of the study indicate a positive correlation between muscle mass and handgrip strength. Players with higher muscle mass generally achieve greater handgrip strength values, confirming the importance of muscle mass in the development of maximal strength. An increased body fat percentage negatively affects handgrip strength due to an unfavorable distribution of mass relative to functional muscle power. Furthermore, the distribution of muscle mass between the upper and lower extremities may influence the ability to generate force during the dynamometer test. The findings of this study emphasize the importance of monitoring body composition in football players to optimize strength training and improve overall performance.*
***Key words**: body composition, muscle mass, body fat, handgrip strength, football players, athletes*

INTRODUCTION

Body composition is considered one of the fundamental determinants of physical performance in youth athletes, as it directly influences strength, endurance, motor coordination, and overall athletic potential. In growing athletes, particularly those engaged in sports requiring repeated high-intensity efforts such as football, optimal levels of skeletal muscle mass and controlled body fat are essential for maintaining performance efficiency and reducing injury risk (Murtagh et al., 2018; Hammami et al., 2020). Handgrip strength (HGS) is widely recognized as a simple, reliable, and valid indicator of overall muscular strength in children and adolescents, and it has been strongly associated with maturation status, neuromuscular development, and long-term athletic potential (Lima et al., 2020; Vicente-Rodríguez et al., 2021).

Previous research demonstrates that higher muscle mass is consistently linked to superior strength performance in youth populations, including young football players, where strength capacity directly contributes to key actions such as tackling, shielding, and explosive locomotion (Deprez et al., 2015; Mala et al., 2019). Studies have also shown that increased body fat percentage negatively affects functional strength outcomes by imposing greater non-functional mass and altering movement mechanics (Matta et al., 2020; Milanese et al., 2021). This is particularly relevant during puberty, when rapid anthropometric and hormonal changes can produce substantial inter-individual variability in performance.

In football-specific contexts, handgrip strength has been examined both as a predictor of general neuromuscular ability and as a maturational marker, with evidence suggesting that stronger players tend to perform better in sprinting, jumping, and change-of-direction tasks (Peña-González et al., 2019; Silva et al., 2021). Despite the extensive scientific attention directed toward body composition and performance metrics in youth athletes, limited research has simultaneously examined the relationship between body composition parameters and handgrip strength using multiple assessment technologies. Considering that devices such as InBody, Tanita and Omron differ in their measurement algorithms and segmental analysis capabilities, understanding their relevance in evaluating young football players is critical for applied sports science practice.

Given the need for evidence-based monitoring tools in talent development systems, investigating how body composition parameters correspond to functional strength is essential for optimizing training strategies and guiding long-term athlete development. Therefore, the aim of this study is to analyze the relationship between body composition characteristics and handgrip strength in football players aged 11 to 15 years. Insights gained from this research may help coaches, conditioning specialists, and practitioners adjust strength and conditioning programs to better support the physiological needs of youth athletes.

METHODS

Participants

The study included 62 male youth football players, aged 11 to 15 years, recruited from regional football academies. All participants had a minimum of two years of systematic football training and were free from injuries or medical conditions that could affect strength performance or body composition assessment. Prior to participation, written informed consent was obtained from the parents or legal guardians of each athlete, and the study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Study Design

A cross-sectional design was used to investigate the relationship between body composition parameters and handgrip strength. All measurements were conducted during a single assessment session under standardized laboratory conditions. Participants were tested individually and instructed to avoid strenuous activity for at least 24 hours before testing.

Body Composition Assessment

Body composition was evaluated using three bioelectrical impedance analysis (BIA) devices to ensure measurement reliability and cross-device comparison:

1. InBody 270 (InBody Co., South Korea)
2. Omron BF511 (Omron Healthcare, Japan)
3. Tanita BC-418 MA (Tanita Corporation, Japan)

All devices were calibrated before testing. Measurements included:

- Total body mass (kg)
- Body mass index (BMI)
- Skeletal muscle mass (SMM)
- Body fat percentage (BF%)
- Segmental muscle distribution (upper and lower limbs)

Participants were assessed barefoot, in light clothing, following a 3-hour fasting window as recommended in pediatric BIA protocols.

Handgrip Strength Testing

Handgrip strength was measured using a Jamar hydraulic dynamometer, a validated and widely used tool in pediatric strength assessment. The testing protocol followed the standardized procedure recommended by the American Society of Hand Therapists:

- Participants were seated with the shoulder adducted and neutrally rotated.
- The elbow was flexed at 90 degrees, the forearm in a neutral position, and the wrist between 0–30° extension.
- Three maximal contractions were performed with the dominant hand, with a 60-second rest between trials.

The highest value (kg) was used for further analysis. Handgrip strength is recognized as a reliable indicator of overall muscular strength and maturation in youth athletes (Lima et al., 2020; Vicente-Rodríguez et al., 2021).

Procedures

All testing was supervised by trained evaluators with experience in pediatric strength and body composition assessment. The testing order was identical for all participants:

1. Body composition (InBody → Omron → Tanita)
2. Five-minute standardized warm-up (light jogging and mobility exercises)
3. Handgrip strength testing

Participants were instructed to maintain normal hydration throughout the testing day. Environmental conditions (temperature 22–24°C) were kept constant.

Statistical Analysis

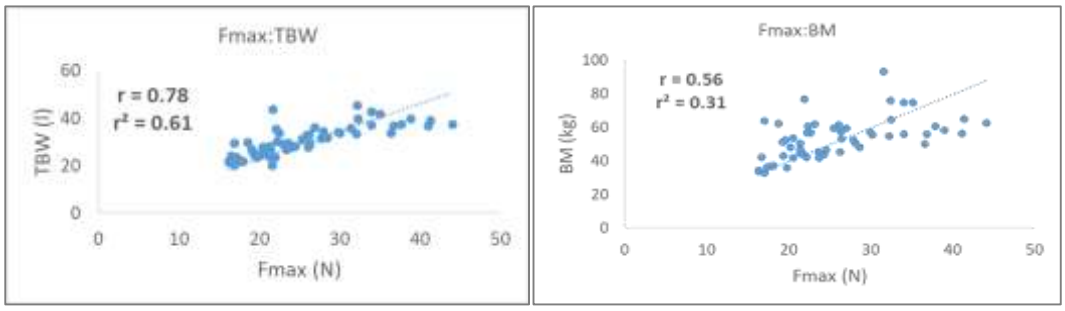
All data were analyzed using SPSS 26.0 (IBM Corp., USA). Descriptive statistics (mean ± SD) were calculated for all variables. Pearson correlation coefficients were used to evaluate relationships between:

- Handgrip strength and skeletal muscle mass
- Handgrip strength and body fat percentage
- Handgrip strength and BMI
- Handgrip strength and segmental muscle distribution

RESULTS

The results of the study are presented in the following section and include descriptive characteristics of the participants, as well as correlation analyses examining the relationship between maximal handgrip strength and selected body composition parameters. All findings are displayed through summary tables and graphical illustrations to facilitate interpretation.

Figure 1 Relationship between maximal handgrip strength (Fmax) with total body water (TBW) and body mass (BM)

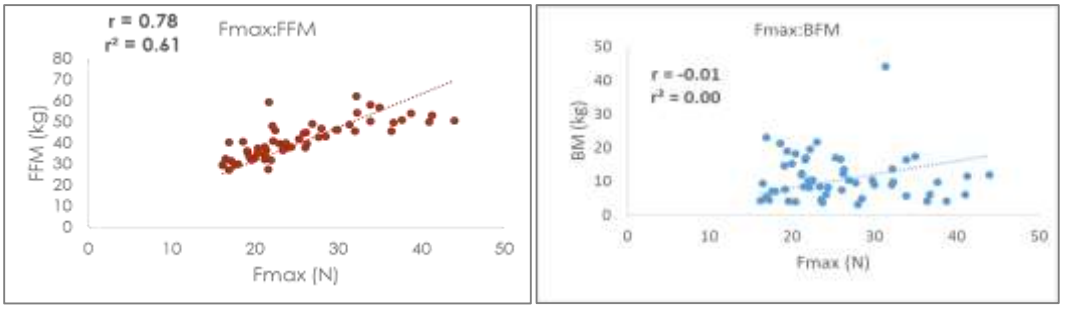


Legend: Fmax – maximal handgrip strength; TBW – total body water; BM – body mass.

The correlation analysis revealed notable relationships between maximal handgrip strength and basic body composition indicators. Total body water demonstrated a strong positive correlation with Fmax ($r = 0.78$; $r^2 = 0.61$), indicating that higher levels of lean, hydration-related tissue are closely associated with improved strength performance in young football players. Body mass also showed a moderate positive correlation with handgrip strength ($r = 0.56$; $r^2 = 0.31$), suggesting that overall mass contributes to strength output, but to a lesser extent than lean tissue components. These findings highlight that increases in functional, non-fat tissue appear to be more influential for maximal grip force than increases in total body mass alone.

The analysis revealed a markedly different contribution of fat-free and fat mass to maximal grip performance. Fat-free mass showed a robust positive correlation with Fmax ($r = 0.78$; $r^2 = 0.61$), indicating that increases in structurally and metabolically active tissue substantially enhance the ability to generate maximal force. This finding aligns with established physiological principles suggesting that neuromuscular capacity is largely driven by the quantity and functional quality of lean mass.

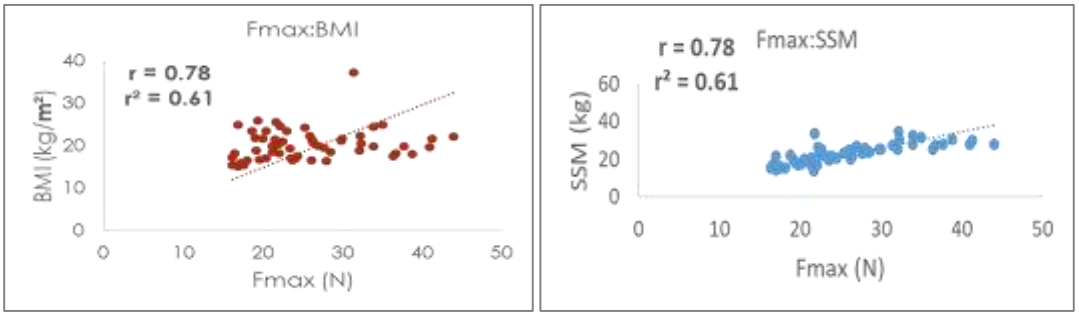
Figure 2 Relationship between maximal handgrip strength (Fmax) with fat-free mass (FFM) and body fat mass (BFM)



Legend: Fmax – maximal handgrip strength; FFM – fat-free mass; BFM – body fat mass.

In contrast, body fat mass exhibited no association with handgrip strength ($r = –0.01$; $r^2 = 0.00$). The absence of a meaningful relationship suggests that adipose tissue does not contribute to force production and may represent non-functional load with no influence on upper-limb strength in this age group. These results emphasize the dominance of fat-free tissue in determining maximal isometric strength during early and mid-adolescence.

Figure 3 Relationship between maximal handgrip strength (Fmax) with body mass index (BMI) and segmental skeletal muscle mass (SSM)



Legend: Fmax – maximal handgrip strength; BMI – body mass index; SSM – skeletal muscle mass.

The findings reveal that BMI exhibits a strong positive association with maximal handgrip strength ($r = 0.78$; $r^2 = 0.61$). Although BMI is a composite index that does not distinguish between adipose and lean tissue, its strong correlation in this cohort likely reflects the predominance of muscle mass within the developmental stage of these athletes. This suggests that higher BMI values in trained youth may be indicative of increased functional tissue rather than excess fat.

Similarly, segmental skeletal muscle mass demonstrated an equally strong correlation with Fmax ($r = 0.78$; $r^2 = 0.61$). This relationship underscores the importance of regional muscular development—particularly in the upper body—for maximal isometric force output. Given that handgrip performance is influenced by both local and systemic neuromuscular factors, the strong association with SSM highlights the relevance of targeted muscle development during adolescence.

DISCUSSION

The primary aim of this study was to examine the relationship between body composition parameters and maximal handgrip strength in young football players aged 11 to 15 years. The obtained results consistently demonstrated that indicators of lean body composition—including total body water (TBW), fat-free mass (FFM), skeletal muscle mass (SSM), and BMI (as an indirect anthropometric marker)—show strong positive correlations with handgrip strength. In contrast, body fat mass (BFM)

showed no association with strength output. These findings align with existing literature emphasizing the essential role of lean tissue in the development of neuromuscular strength in youth athletes.

A key outcome of this study is the strong correlation between FFM and handgrip strength (r = 0.78), indicating that increases in non-fat tissue are directly associated with greater force production. Similar relationships have been reported in previous studies, where FFM has been recognized as a dominant predictor of strength, power, and overall physical performance in young athletes (Mala et al., 2019; Hammami et al., 2020). Vicente-Rodríguez et al. (2021) also reported that children and adolescents with higher levels of fat-free mass exhibit significantly better performance in both isometric and dynamic strength tasks, supporting the role of lean mass as a fundamental component of muscular function.

The results also showed a strong association between TBW and handgrip strength. Given that TBW represents a major physiological component of fat-free tissue and reflects the hydration of metabolically active compartments, this finding aligns with previous evidence suggesting that cellular hydration status plays a significant role in muscle contractility and overall strength expression (Matta et al., 2020). Adequate hydration and intracellular water content have been linked to improved muscular performance, particularly in youth athletes undergoing rapid growth and tissue expansion.

Furthermore, skeletal muscle mass (SSM) demonstrated a strong positive correlation with Fmax. This supports earlier findings indicating that regional and segmental muscle development, especially in the upper extremities, contributes substantially to handgrip performance (Deprez et al., 2015; Peña-González et al., 2019). Since handgrip strength is influenced by both local muscle size and systemic neuromuscular development, the strong relationship with SSM reinforces the importance of targeted muscle development during adolescence.

Interestingly, BMI also showed a strong positive correlation with grip strength, which is consistent with research suggesting that higher BMI values in athletic youth populations often reflect greater muscle mass rather than excess fat (Milanese et al., 2021). In this study, the strong association between BMI and Fmax likely reflects the developmental characteristics of football players, who typically accumulate muscle mass due to regular training stimuli. This confirms earlier observations by Silva et al. (2021), who found that BMI may serve as a practical, albeit indirect, indicator of physical performance in adolescents involved in structured training programs.

In contrast, body fat mass demonstrated no meaningful association with handgrip strength. This finding is consistent with prior research indicating that excess adipose tissue does not contribute to force production and may even act as non-functional mass that impairs performance in certain motor tasks (Murtagh et al., 2018). Milanese et al. (2021) similarly reported that higher body fat percentages negatively influence strength, speed, and agility in young football players, reinforcing the concept that adipose tissue plays no functional role in the development of muscular strength.

Overall, the results of this study support the conclusion that lean body components, particularly fat-free mass and skeletal muscle mass, are strong predictors of handgrip strength in young football players. Handgrip strength has been widely recognized as a reliable indicator of general muscular fitness and maturational development (Lima et al., 2020), and the present findings further confirm its value in the assessment of youth athletes. Given the substantial inter-individual variation observed in this age group due to different maturation rates, the strong associations identified in this study highlight the importance of continuous monitoring of body composition to optimize training interventions, talent development, and long-term athletic progression.

These findings extend the current body of knowledge by simultaneously analyzing multiple body composition technologies (InBody, Tanita, Omron) and revealing consistent correlations across different measurement systems. This supports the practical application of BIA devices in sports settings where rapid, non-invasive assessments are required.

CONCLUSION

The findings of this study indicate that lean body composition components—including total body water, fat-free mass, skeletal muscle mass, and BMI (as an indirect anthropometric indicator)—are strongly associated with maximal handgrip strength in young football players aged 11 to 15 years. These results demonstrate that strength performance in this population is predominantly influenced by

metabolically active and functionally relevant tissue, while body fat mass shows no meaningful relationship with force production.

Given the importance of muscular development during adolescence, monitoring body composition through reliable and accessible assessment tools provides valuable insights for coaches, conditioning specialists, and practitioners working in youth football. The strong associations identified in this study support the use of handgrip strength as a practical indicator of neuromuscular development and an important component of talent identification and long-term athletic development. Future research should explore longitudinal changes and the influence of maturation status to further clarify developmental patterns in strength and body composition among youth athletes.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to the participating football academies, coaches, and young athletes for their cooperation and commitment throughout the data collection process. Appreciation is also extended to the evaluators and staff members who assisted in conducting the assessments.

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POVEZANOST TELESNE KOMPOZICIJE I SNAGE STISKA ŠAKE KOD MLADIH FUDBALERA

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***Sažetak**: Cilj ovog istraživanja je analiza povezanosti različitih parametara telesne kompozicije sa snagom stiska šake kod fudbalera uzrasta od 11 do 15 godina. Snaga stiska šake merena je dinamometrom, dok su merenja telesne kompozicije sprovedena korišćenjem tri različita uređaja: In Body, Omron i Tanita. Telesna kompozicija, uključujući mišićnu masu , procenat telesne masti, indeks telesne mase i segmentnu distribuciju mišićne mase, može značajno uticati na performanse snage. Rezultati istraživanja ukazuju na pozitivnu korelaciju između mišićne mase i snage stiska šake. Igrači sa većom mišićnom masom u proseku postižu veće vrednosti sile stiska, što potvrđuje značaj mišićne mase u razvoju maksimalne sile. Povećan procenat telesne masti pokazuje negativan uticaj na snagu stiska zbog*

nepovoljne distribucije mase u odnosu na funkcionalnu mišićnu snagu. Takođe, distribucija mišićne mase između gornjih i donjih ekstremiteta može uticati na sposobnost generisanja sile tokom izvođenja testa na dinamometru. Zaključak ovog istraživanja naglašava važnost praćenja telesne kompozicije fudbalera kako bi se optimizovao trening snage i poboljšale ukupne performanse.

***Ključne reči**: telesna kompozicija, mišićna masa, telesna mast, snaga stiska, fudbaleri, sportisti*