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DIFFERENCES IN BODY COMPOSITION AND HANDGRIP STRENGTH AMONG 12–15-YEAR-OLD FOOTBALL PLAYERS FROM NORTHEASTERN ROMANIA

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ABSTRACT. *Introduction:* Early adolescence is marked by a series of anatomical and functional changes. Understanding these functional adaptations is particularly relevant for football coaches, as they influence training strategies and performance development. *Objective:* This study aimed to examine age-related differences in body composition parameters and handgrip strength among junior football players. *Materials and Methods:* Between September 2024 and August 2025, 151 male football players aged 12 (n=18), 13 (n=35), 14 (n=45), and 15 years (n=53) were assessed. Handgrip dynamometry is widely recognized in literature as a reliable measure of overall muscular strength in athletes. Two Constant hand dynamometers (model 14192-760E) were used, with participants performing maximal voluntary contractions while standing, arms fully extended and held obliquely laterally. *Results:* Significant anthropometric increases were observed between ages 13 and 14, whereas BMI remained consistent across age groups. Muscle mass increased from 39.06 ± 2.21% at age 13 to 41.09 ± 1.37% at age 14, while body fat percentage did not change significantly. No significant differences were observed in handgrip strength, despite notable changes in body composition. *Conclusions:* Handgrip strength assessment represents a practical tool for monitoring and evaluating muscular strength in adolescent athletes. The data provided by this study may serve as reference values for coaches in the region. In this cohort, early adolescence was associated with nonsignificant changes in handgrip strength, despite measurable alterations in body composition.

Keywords: handgrip strength; football; anthropometry; body composition; early adolescence.

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INTRODUCTION

During adolescence (11–16 years) substantial morphological, hormonal, and functional changes occur. These are evident in body mass, fat-free mass (FFM), muscle mass, and body fat. Functional adaptations follow, with strength increasing as chronological age advances.

Anthropometric transformations are particularly relevant in football, since they may influence not only physical performance but also injury risk, energy-use efficiency, and adaptation to competitive demands.

Assessment and monitoring of body composition in adolescent athletes have high practical and scientific importance. Likewise, knowledge of strength levels benefits athletic preparation, because associations exist between body composition and motor qualities. In particular, muscle mass and body fat affect running speed, explosive strength and endurance. Coaches and multidisciplinary sport-science staff can use monitoring of body composition and strength to individualize training and to prevent injuries (Leão et al., 2022).

Between 12 and 15 years, growth and development are characterized by large fluctuations. Height changes and endocrine events produce unpredictable performance outcomes for athletes who previously showed great promise in their pre-adolescent motor behavior. This implies the need to adapt football training plans; interpreting anthropometric data appropriately is key to the success of individualized interventions (Nikolaidis & Karydis, 2011).

Adolescents show marked variability in body-composition and strength indicators. Sources of this variation include chronological age, biological maturation, characteristics of sport training, and other factors. Physical-criteria selection in academies is therefore challenging and requires careful attention. An increase in strength with advancing age and biological maturation has been documented; handgrip strength is influenced by changes in body size and by maturation stage (Malina et al., 2004).

Recent studies have produced normative data for body composition and handgrip strength in adolescents from European and South American populations, though few studies have focused on Eastern Europe for the 12–15-year age range. Measurements of football players in U15, U17 and U19 categories revealed increases in muscle mass and moderate reductions in adipose tissue in the older age groups (Spehnjak et al., 2021).

Longitudinal cohort studies have shown that ongoing football practice reduces body-fat percentage and increases fat-free mass. This effect was observed in a sample of adolescent boys who achieved significant improvements after 12 months of regular training, accompanied by increases in handgrip strength (França et al., 2023).

Handgrip strength testing is simple and reliable, easy to administer, and requires less space and equipment compared with many other strength assessments. In youth, handgrip strength correlates with overall strength and with functional muscle quality. It is frequently included in junior test batteries because it correlates with various physical parameters such as isometric strength, speed, and lower-limb explosive power (Naimo & Gu, 2022).

Optimization of handgrip strength is associated with chronological age and biological maturation. A recent study examined relationships among handgrip strength, vertical and horizontal jump performance, sprint speed, chronological age and maturation. Strong associations were found with the first three performance measures and moderate associations with age and maturation. The sample comprised 221 football players aged 11–19 years (Schulz et al., 2025).

The importance of maturation was demonstrated in a study of U14 players in Brazil undergoing sports selection: compared with those who were not selected, the chosen athletes showed superiority in sexual maturation, salivary testosterone levels and handgrip strength (Massa et al., 2022).

Responses to strength-specific training vary with maturation stage and less so with the specific characteristics of the training program. For this reason, inclusion of anthropometric parameters in analyses of adolescents is recommended (Retzepis et al., 2025).

Biological maturation plays a major role in differentiating individuals of the same chronological age with respect to anthropometric components and aptitude-related traits. Implementation of strength programs in young athletes produces different outcomes depending on maturation stage (Peña-González et al., 2019).

Beyond mere participation in the sport, body composition and strength are affected by playing position, training frequency, training volume, and individual differences in biological maturation. Among players aged 14–15 years, differences have been observed in body mass, height, muscle mass, body fat and handgrip strength (Łuszczki et al., 2025).

Results obtained from a given geographic area can be used by sport and education specialists to seek optimal strategies for physical development of the adolescents they train (Oliver et al., 2023).

Although abundant normative references exist in the international literature, applying them to populations such as adolescents from north-eastern Romania may be problematic because training practices and socio-cultural or socio-economic characteristics can differ from those of the samples on which the published norms are based. Our study thus has practical value for coaches and teachers in the region by guiding training planning and talent identification at the local/regional level (Hermassi et al., 2023).

The present study aims to analyze the development of body composition and handgrip strength in football players aged 12–15 years from north-eastern Romania. Grouping of the athlete cohort is based on chronological age. The results may enrich local and regional reference data and provide coaches with information to refine training decisions grounded in sport monitoring.

Consistent with findings in the literature, our hypothesis is that, in adolescent football players from north-eastern Romania, body composition will change with increasing age between 12 and 15 years – specifically, an increase in muscle mass percentage and a decrease in body fat percentage – and that handgrip strength will increase with age.

MATERIAL AND METHODS

Participants

From an initial cohort of 212 boys, 151 were selected for assessment of body composition and handgrip strength. Inclusion criteria were: chronological age between 12 and 15 years, regular participation in football training, and geographic residence in north-eastern Romania. The selected athletes were registered with four sports clubs located in Iasi and Suceava counties. To examine age-related development, the sample was stratified into four age groups: 12-year-olds (n = 18), 13-year-olds (n = 35), 14-year-olds (n = 45), and 15-year-olds (n = 53). Their characteristics are summarized in Table 1.

The study protocol was approved by the Scientific Research Ethics Committee of the Faculty of Physical Education and Sport, Iasi (Approval No. 24/28.02.2023) and was conducted in accordance with the Declaration of Helsinki.

Procedure

During the 2024/2025 competitive season, participants were recruited and measured on-site at their respective clubs by an assessment team composed of students from the Selection and Sports Counseling Center, Faculty of Physical Education and Sport, Iasi. Each member of the research team received training prior to data collection.

The study variables comprised body-composition parameters (height, body mass, BMI, body fat, and muscle mass) and handgrip strength (dominant handgrip, nondominant handgrip, and mean handgrip).

Body composition was assessed using an OMRON BF-511 body composition analyzer (bioelectrical impedance). Height was measured barefoot on a horizontal surface prior to stepping onto the analyzer. A Handy60 electronic level with an attached Bosch GLM80 professional laser distance meter was used for the height measurement. After entering the participant's personal data (age, sex, and height) into the device, the subject mounted the body analyzer barefoot and was handed the analyzer's control unit, which they grasped with the hands in pronation. During the measurement the arms were extended forward with the hands positioned at shoulder level. When the measurement was complete, the values displayed by the device were recorded on the results form.

Handgrip strength was measured with two Constant hand dynamometers (Constant, Guangdong, China; model 14192-760E) using a squeeze/pressure mechanism. The grip span of each dynamometer was set at the midpoint. Each participant performed maximal voluntary grips simultaneously with both hands while standing, with the arms positioned obliquely at the sides and the palms facing forward. Each contraction lasted 3–5 seconds to allow attainment of the maximal value. Two trials were recorded, and the trial with the highest combined (summed) value from the two dynamometers was used for analysis.

All measurement sessions were audio-recorded to allow subsequent verification of the recorded results and to correct any transcription errors.

Data analysis

All data were entered into a Microsoft Excel database and subsequently exported to GraphPad Prism version 10.4.2 (GraphPad Software, Inc.) for analysis. Outliers were identified and removed using the ROUT method ($Q = 1\%$), resulting in the exclusion of $n = 8$ observations. The normality of the data distribution was then assessed. Between-group differences attributable to chronological age were examined for each anthropometric and strength parameter using one-way ANOVA. Where the ANOVA indicated a significant effect, Tukey's multiple-comparisons test was applied to identify pairwise differences between adjacent age groups (i.e., year-to-year comparisons). Statistical significance was set at $p < 0.05$.

RESULTS

Consistent with our study hypothesis, the data are presented in Table 1 for the four analyzed age groups. For each variable, the F statistic and significance level from the one-way ANOVA are reported.

Significant differences were observed for height ($F(3,147) = 26.97$, $p < 0.0001$), body mass ($F(3,147) = 18.26$, $p < 0.0001$), BMI ($F(3,141) = 5.11$, $p = 0.0022$), and muscle mass ($F(3,110) = 13.97$, $p < 0.0001$). In contrast, body fat ($F(3,110) = 1.99$, $p = 0.12$) and handgrip strength ($F(3,146) = 1.72$, $p = 0.166$) showed no significant differences between the age groups.

Table 1. Anthropometric characteristics and handgrip strength by chronological age

	12 years (n=18)	13 years (n=35)	14 years (n=45)	15 years (n=53)	F	p
Height (cm)	159.9±7.02	162.1±10.4	171.8±6.31	174.6±7.79	$F_{(3, 147)}$ = 26.97	<0,0001
Body mass (kg)	51.59±9.77	50.34±10.03	59.16±7.33	62.62±7.78	$F_{(3, 147)}$ = 18,26	<0,0001
BMI (kg/m2)	19.49±2.39	18.95±2.2	19.83±1.64	20.46±1.33	$F_{(3, 141)}$ = 5.11	0.0022
Body fat (%)	14.26±5.38	14.92±4.94	12.35±3.55	13.64±3.68	$F_{(3, 110)}$ = 1.99	0.12
Muscle mass (%)	39.45±2.5	39.06±2.21	41.09±1.37	41.73±1.53	$F_{(3, 110)}$ = 13.97	<0,0001
Dominant handgrip (kg)	33.79±18.66	27.55±12.66	32.09±5.91	31.86±6.2	$F_{(3, 147)}$ = 2.12	0.099
Nondominant handgrip (kg)	24.79±8.96	26.82±12.26	29.73±5.38	29.87±6.16	$F_{(3, 145)}$ = 2.45	0.066
Average handgrip (kg)	29.21±13.15	27.19±11.42	30.91±5.38	30.86±5.79	$F_{(3, 146)}$ = 1.72	0.166

*Significant differences, $p< 0.05$

Based on Tukey's multiple-comparisons test results, the pairwise differences between groups were plotted for each variable. Of primary interest were the significant year-to-year (adjacent-age) differences, although meaningful interpretations can also be drawn from the other observed changes.

Our results demonstrate anthropometric changes reflected by differences in height and body mass (Table 1). In Figure 1A there is a year-to-year increase

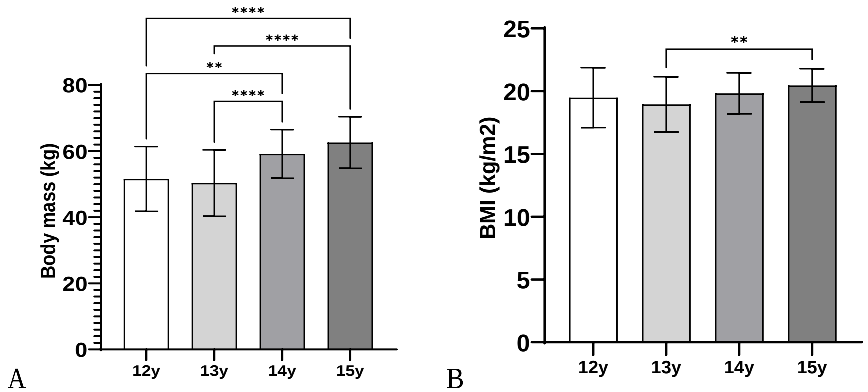

Fig. 1. Intra-individual changes between age groups for body mass (A) and BMI (B)

in body mass, with a significant change observed between 13 years (50.34 ± 10.03 kg) and 14 years (59.16 ± 7.33 kg). In Figure 1B, BMI changed only between 13 and 15 years ($p = 0.0011$); there was no progressive, linear effect of advancing age on BMI.

Consistent with the increases in body mass, percent muscle mass showed a marked rise during early adolescence (Figure 2A). Specifically, muscle mass increased from 39.06 ± 2.21% at 13 years to 41.09 ± 1.37% at 14 years; one-way ANOVA indicated a significant group effect ($F(3,110) = 13.97$, $p < 0.0001$), and post hoc comparisons identified the 13→14 year change as significant. By contrast, body-fat percentage displayed only minor fluctuations and remained essentially stable between 12 and 15 years (Figure 2B), in agreement with the non-significant ANOVA result for body fat ($F(3,110) = 1.99$, $p = 0.12$).

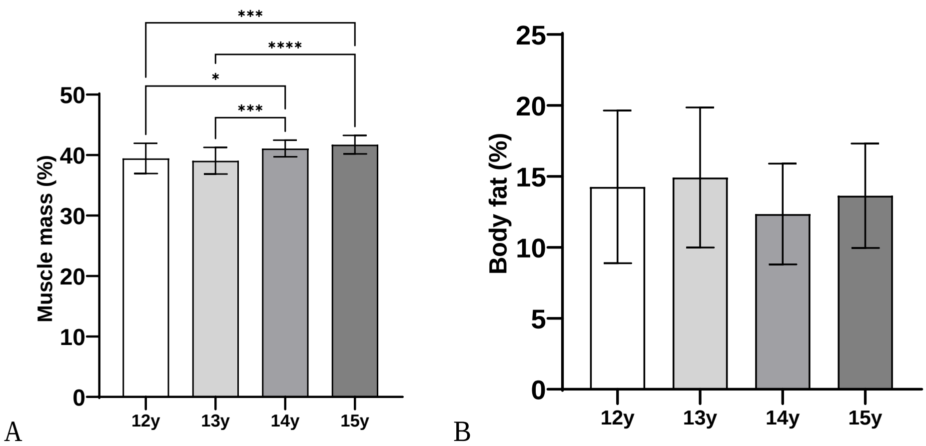

Fig. 2. Intra-individual changes between age groups for muscle mass (A) and body-fat percentage (B)

Handgrip strength remained relatively unchanged across the four age groups. On the dominant side (Figure 3A), results showed inconsistency, a trend that was also observed in the overall average of both hands (Figure 3C). In contrast, the non-dominant hand (Figure 3B) exhibited a moderate increase in mean strength, from 24.79 ± 8.96 kg at age 12 to 29.87 ± 6.16 kg at age 15. However, these differences did not reach statistical significance ($F(3,146) = 1.72$; $p = 0.166$).

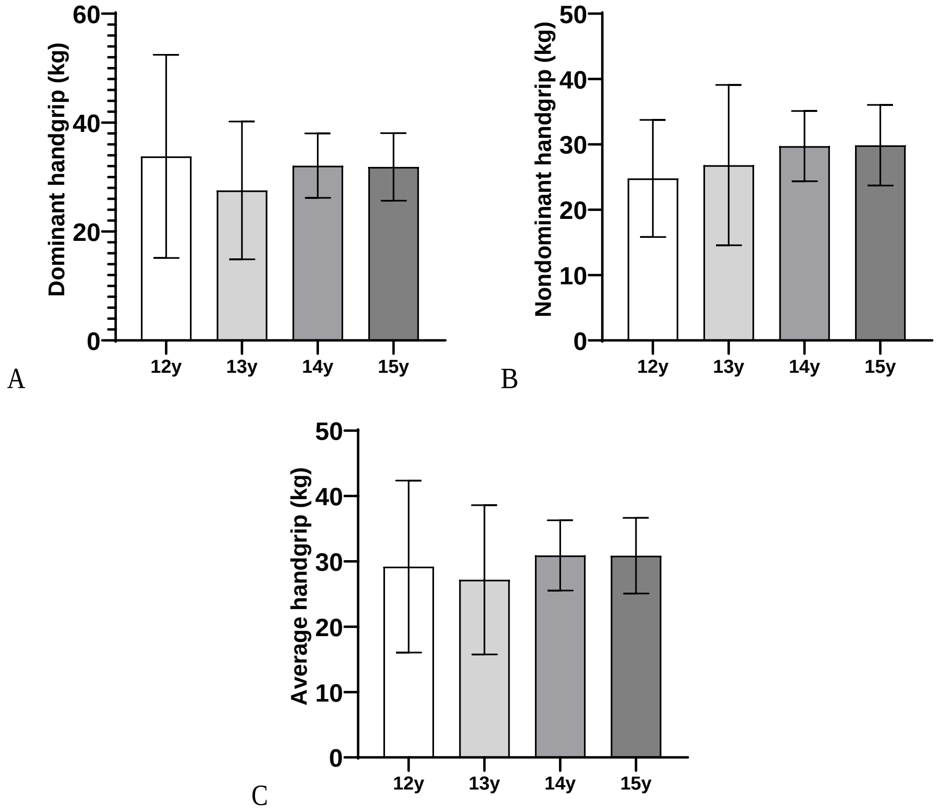

Fig. 3. Intra-individual changes between age groups for dominant (A), non-dominant (B), and average handgrip strength (C)

DISCUSSION

Our study aimed to analyze the effect of chronological age on body composition parameters and handgrip strength among adolescent football players. The reported data have practical relevance for coaches and physical education teachers involved in monitoring and optimizing the physical development of young athletes.

The results indicate that body mass increases in parallel with a rise in the percentage of muscle mass. Chronological age significantly influences these changes, particularly during the transition from 13 to 14 years of age, suggesting that this stage represents a key point in somatic and functional development.

Other variables remained unchanged, providing only partial support for our initial hypothesis. Although most parameters showed fluctuations in value, the mean non-dominant handgrip strength followed an upward trend. However, this progression was not sufficient to reach statistical significance.

Body Composition

The observed increases in height and body mass among participants aged 12 to 15 years are consistent with trends reported in previous studies. This developmental pattern reflects the pubertal growth spurt, during which rapid somatic and physiological changes occur. Such transformations help explain the fluctuations often seen in adolescents' physical performance. Malina et al. (2004) reported that players aged 13–15 years exhibit considerable variation in functional capacity, largely due to the influence of biological maturation and anthropometric changes.

Changes in BMI across age groups are closely related to the combined effects of body mass and height increases. Among adolescent athletes, this progression is common; however, BMI alone provides limited insight into body composition and should be interpreted alongside additional indicators. Leão et al. (2022) demonstrated that in youth athletes, isolated BMI assessment is insufficient for accurately describing body composition.

Spehnjak et al. (2021) observed that U15 players exhibited increases in fat-free mass percentages, accompanied by stable or slightly reduced body fat levels. Consequently, an upward change in BMI cannot be attributed solely to increased adipose tissue.

The lack of statistically significant differences in body fat percentage among the four age groups may be explained by individual variability in biological maturation. Regular football training has been associated with reductions in body fat, although such effects typically emerge over longer time frames. Spehnjak et al. (2021) also noted that while consistent participation in training tends to decrease adipose tissue, individual variability remains high.

The cross-sectional design of the present study and the diverse training regimens of participants may have contributed to the absence of significant changes in fat percentage. A longitudinal approach could more effectively capture the influence of chronological age on body composition. Additionally, the electrical bioimpedance method used in this study is sensitive to hydration status—a factor that, although communicated to participants, could not be fully controlled by the research team.

In older age groups (U15–U17), a gradual decline in body fat percentage has been reported, although differences remain small and population-dependent. The proportional increase in both height and fat-free mass may result in the relative stability of body fat levels observed in younger football players (Spehnjak et al., 2021).

Consistent with previous findings, muscle mass demonstrated an expected increase, primarily driven by the physiological changes associated with puberty and the physical demands of football training. Positive correlations have been identified between increased muscle mass and indices of strength and power among youth players in the U14 and U15 categories (Leão et al., 2022).

Handgrip strength

Handgrip strength did not change significantly across the studied age groups, a finding that aligns with parts of the existing literature emphasizing the predominant role of biological maturation over chronological age. Gómez-Campos et al. (2018) demonstrated that differences in handgrip strength among adolescents are more strongly influenced by the level of biological maturation than by chronological age itself.

There is a well-established congruence between muscular development and the accumulation of fat-free mass during adolescence, reflecting the physiological transformations that accompany growth and maturation. Konarski et al. (2024) identified height, body mass, fat-free mass, and skeletal maturation as major predictors of strength development when age was considered as the independent variable (Konarski et al., 2024).

Another important consideration concerns the specificity of the sport. Disciplines that involve frequent gripping actions—such as climbing or gymnastics—demonstrate clear differences in handgrip strength across age categories. Since football is a sport in which upper-limb muscular engagement is relatively limited, greater variability in handgrip strength may be expected among players. Moreover, the lack of targeted upper-body and forearm training in certain geographic regions could also explain the modest progression observed in this parameter.

Given the strong correlation between handgrip strength and overall muscular strength, its interpretation should be contextualized within the broader framework of total muscle mass and training specificity (Abe et al., 2024; Jansson et al., 2025).

CONCLUSIONS

The results of our study reveal particular trends when compared with existing literature. In certain aspects—such as body mass and muscle mass—our findings align with the general growth and developmental patterns observed among adolescent athletes. However, the remaining parameters, although initially expected to follow an upward trajectory, displayed stagnation and fluctuations consistent with the physiological variability characteristic of the 12–15 age interval.

The group of adolescent male football players partially confirmed our hypothesis through significant changes in body mass and muscle mass, with a clear threshold of growth observed between ages 13 and 14. Other anthropometric and strength-related variations may be attributed to differences in biological maturation, which appear to exert a stronger influence than chronological age. Among adolescent boys, chronological age does not represent a reliable indicator of physical development. Consequently, handgrip strength does not seem to be directly influenced by age progression, reflecting instead individual maturation patterns and sport-specific physical demands.

Considering the relatively small sample size and limited age range, the data presented here may still hold practical relevance for coaches and physical education professionals in northeastern Romania. Handgrip strength can be easily assessed and provides valuable information that can be integrated into athletic training programs.

Given the current context in which Romanian football faces challenges on the international stage, we emphasize the need for a multilateral physical preparation approach. Developing overall strength capacities may enhance competitiveness and contribute to improved athletic performance among young Romanian football players.

AUTHOR CONTRIBUTIONS

Florin-Petruț TROFIN and Cezar HONCERIU contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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