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Somatotype as a Predictor of Physical Fitness in Young Male Football Players

Zhikica Tasevski[1], Seryozha Gontarev[1], Borce Daskalovski[1], Luka Popovski[1]

AFFILIATIONS

[1]Ss. Cyril and Methodius University-Skopje, Faculty of Physical Education, Sport and Health, Skopje, North Macedonia

CORRESPONDENCE

Z. Tasevski, Ss.Cyril and Methodius University in Skopje, Faculty of Physical Education, Sport and Health, 3 Dimche Mirchev, 1000 Skopje, North Macedonia, *tasevskizikica@yahoo.com*

Abstract

The purpose of this study was to investigate the relationship and predictive value of somatotype components for selected indicators of physical fitness in adolescent male soccer players. A sample of 110 boys aged 13-15 years, engaged in structured training, was included. Somatotype was determined using the Heath–Carter method (endomorphy, mesomorphy, ectomorphy). Physical fitness was assessed through agility (zig-zag test), muscular endurance (trunk lifts in 30 seconds), explosive strength (standing long jump), sprint speed (10 m, 20 m, 30 m), and aerobic capacity (Leger test). Pearson's correlation and multiple linear regression (OLS) were applied. Mesomorphy showed a strong positive association with abdominal endurance (β=0.555; p<0.001) and negative correlations with sprint time at 10 m (r=-0.329; p<0.01) and 30 m (r=-0.258; p<0.05). Ectomorphy was associated with slower sprint times, particularly at 10 m (r=0.418; p<0.01), while endomorphy was negatively related to explosive strength (r=-0.296; p<0.01) and aerobic capacity (β=-0.228; p=0.013). The regression models accounted for 6.9%–21.1% of the variance in the performance tests. Somatotype components are significant predictors of specific physical fitness attributes in adolescent soccer players. Integrating somatotype assessment into training programs may support more effective individualization of training and talent identification.

Keywords: *Heath-Carter method, endomorphy, mesomorphy, ectomorphy, sprint performance, talent identification*

Introduction

Modern trends in sports science confirm the importance of body structure and morphological characteristics as key factors in determining physical performance in young athletes (Marini et al., 2020). The somatotype, defined by the classical Heath–Carter model (Heath & Carter, 1967), represents a stable bio-typological indicator describing three fundamental components: endomorphy (adipose tissue), mesomorphy (muscle development), and ectomorphy (linearity). The balance between these components directly impacts performance in various motor and energy-exerting tasks (Carter & Heath, 1990).

In young footballers, somatotype is a significant biological predictor of physical fitness, since body composition and muscle distribution affect abilities such as speed, explosiveness, agility, and aerobic endurance (Marangoz & Baştürk, 2018). Football, with high physiological demands and frequent transitions between aerobic and anaerobic activities, requires an optimal combination of muscle strength and relatively low fat for efficient performance in high-intensity conditions (Cárdenas-Fernández et al., 2019).

Multiple authors indicate that young footballers most often belong to a balanced mesomorphic somatotype, well-suited for sports demanding strength, endurance, and technical precision (Kastrati et al., 2022). Muscle development in adolescence improves anaerobic power, while reduced fat increases mechanical efficiency and aerobic capacity (Chaouachi et al., 2012). High endomorphic values are associated with poorer agility and reduced speed, due to additional body mass hindering acceleration and directional changes (Özkan & Köklu, 2024).

From a biomechanical perspective, the predominantly mesomorph body type is most often connected to a greater fat-free (muscle) mass and a favourable strength-to-body ratio, which is functionally significant for the high-intensity football movements (accelerations, sprints, jumps, and duels) (Petkovic et al., 2025). Studies analysing players according to their position, additionally show that the somatotype varies in dependence of their role of the field: in Slovak football players (average age around 17) positional differences in the Heath–Carter somatotype classification have been reported, whereby goalkeepers, defenders, and forwards are most often classified as ectomorphic mesomorphs, while midfielders are classified as mesomorphic ectomorphs (Kolena et al., 2024). Similarly, in young professional football players of the U-19 and U-20 categories, one notices a dominance of balanced mesomorph profiles, with significant differences in the bodily composition, category-wise and playing position-wise, which confirms the practical significance of morphological characteristics for sports specialization and adequacy of the position (Zambrano-Villacres et al., 2024).

With regard to sports performances, studies concerning young football players show that biological maturity is a critical moderator: players with the same chronological age may possess different anthropometric and somatotype profiles, depending on their biological age, which is directly reflected in the development of speed and strength (Čaušević et al., 2023). Additionally, recent studies that research sprint in young football players report that anthropometric and mechanical variables influence sprint performance and that body type variations have practical significance in explaining individual speed differences (Bustamante-Garrido et al., 2024).

Apart from the growing number of papers on position profiles and morphological differences, current research still misses studies that systematically quantify the independent predictive value of each somatotype component (endomorphy, mesomorphy, ectomorphy) in trained football players, ages 13 to 15, across a wide battery of field tests relevant for football (agility, muscular endurance, explosive power, sprint performance across multiple distances and aerobic capacity), instead of remaining limited to descriptive comparisons by position. Consequently, the purpose of this study is to check the associations and predictive contributions of somatotype components on the key indicators over the key indicators of physical fitness in young football players in a critical developmental period.

Despite many studies (Kolena et al., 2024; Zambrano-Villacres et al., 2024) confirming the somatotype–physical ability link, few focus on adolescent footballers and biological/morphological asymmetry. This age is critical for forming the athletic profile, showing major variations in growth, muscle mass, and fat distribution (Cárdenas-Fernández et al., 2019).

Therefore, this study examines the ratio and prognostic value of somatotype components on indicators of physical fitness in young male footballers. Mesomorphy is expected to correlate with better strength, agility, and speed; endomorphy with lower explosive and aerobic ability; and ectomorphy with variable effects depending on the test and relative muscle mass. These analyses aim to support talent identification and individualized youth training.

Methods

The study was conducted in accordance with standards in sports science and anthropometry, with a precisely defined sample, measuring instruments, and statistical procedures, in order to ensure the validity and reproducibility of the results.

Participants

The study involved 110 male footballers aged 13 to 15, all active members of registered sports clubs within a structured training program with a minimum of three training sessions per week. The participants had no medical contraindications for participation and had been involved in regular training for at least one year prior to testing. The research was conducted under the ethical principles set out in the Declaration of Helsinki and approved by the institutional Ethics Committee (Number 549, 10.05.2021) Ss. "Cyril and Methodius University" in Skopje

The football players were tested in controlled laboratory and field conditions, in order to minimize the impact of external factors such as fatigue or environmental conditions. The tests took place in the morning, at least 24 hours after the last training session.

Somatotype assessment

Somatotype was determined using the Heath-Carter method (1967), which includes the three components: endomorphy, mesomorphy, and ectomorphy. Standard anthropometric measurements were used to calculate the height, weight, skinfold thickness (of the triceps, subscapular, supraspinal, and medial calf skinfold), upper-arm and calf circumference, and humerus and femur diameters.

All measurements were conducted in accordance with the recommendations of the International Society for the Advancement of Kinanthropometry (ISAK) (Stewart et al., 2011), by using certified equipment, including a Harpenden skinfold calliper (with an accuracy of 0.1 mm), Holtain anthropometer designed for height measurement, and medical scales with a precision of 0.1 kg to measure body mass. All anthropometric measurements were conducted by ISAK certified anthropometrics, following standardized protocols, in order to secure a high level of reliability and validity of the measurements.

Assessment of physical fitness

The assessment of physical fitness was conducted through a comprehensive test battery, selected on account of its proven validity and reliability in the evaluation of the performance capacities in young football players (Krolo et al., 2020). The battery included an agility assessment based on a zig-zag test, where the test-subjects follow a previously defined track around cones in the shortest possible time, whereby a high test-retest reliability has been reported (ICC=0.900-0.970) in young athletes participating in team sports (Kutlu & Doğan, 2018). Muscular endurance was assessed by trunk lifts for a duration of 30 seconds, following a standard protocol widely applied in youth fitness assessments. Explosive strength was measured with a standing long jump, a test that accesses the horizontal power of lower extremities and has been validated as the most reliable field test for muscle fitness in children and adolescents (Ortega et al., 2008), showing a high correlation with lab measurements of power (r=0.780-0.870). Sprint speed was evaluated using electronically timed sprints at 10 m, 20 m, and 30 m, where photocell timing gates enabled precise measurements up to 0.01 s. Aerobic power was assessed through a 20 m multi-stage shuttle run test (Léger test), a progressive maximal test where participants run back and forth on a 20 m track, with incremental speed increases synchronised with audio signals: each stage increases by 0.5 km/h every minute, starting at 8.5 km/h. This test shows high validity (r=0.840-0.920) and reliability (r=0.970) in assessing VO_2max in youth populations (Léger & Lambert, 1982; Léger et al., 1988), making it a suitable field measure for assessing aerobic fitness in young football players.

Statistical analysis

The data were processed in the statistical software SPSS 26.0 (IBM Corp., Chicago, IL). First, the descriptive statistical parameters (arithmetic mean, standard deviation, minimum, maximum, and coefficient of variation) for all variables were calculated. To determine the association between somatotype components and physical fitness indicators, a Pearson correlation analysis was applied, with a level of significance set at p<0.05

To evaluate the predictive value of somatotype components on performance, multivariate linear regression analyses were conducted, using the Ordinary Least Squares (OLS) method. The models included the three somatotype components as independent variables, and the results of fitness tests as dependent variables. Before including them in the analysis, normality of distribution was verified using the Kolmogorov–Smirnov test, and multicollinearity was assessed using the Variance Inflation Factor (VIF) and tolerance indicators.

Results were presented using standardized coefficients (β), the adjusted coefficient of determination (R^2adj), and significance levels, with appropriate interpretation of the biological and practical relevance of the relationships.

Results

To assess the relationship between somatotype components (endomorphic, mesomorphic, and ectomorphic) and physical fitness indicators in subjects, a Pearson correlation analysis (Table 1) was applied. The analysis showed statistically significant negative correlations between the mesomorphic component and the results of the running tests at 10 meters (r=-0.329; p<0.01) and 30 meters (r=-0.258; p<0.05), indicating that higher muscularity is associated with better sprinting performance. Also, mesomorphy showed a strong positive correlation with abdominal strength endurance (r=0.386; p<0.01), which confirms its role in the development of strength capacities.

Table 1. Pearson's correlation between somatotype components and general physical fitness tests

	Endo	Meso	Ecto
Zig-zag test	0.153	-0.202*	0.125
Deep forward bend	-0.049	0.117	-0.136
Trunk lifts for 30 s	0.020	0.386**	-0.012
Standing long jump	-0.296**	-0.208*	0.219*
10 m sprint	-0.004	-0.329**	0.418**
20 m sprint	0.076	-0.111	0.190
30 m sprint	0.021	-0.258*	0.355**
Leger Test	-0.174	0.144	0.083

Note. * Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).

The ectomorphic component showed a positive correlation with sprint times over 10 meters (r=0.418; p<0.01) and 30 meters (r=0.355; p<0.01), indicating an association with poorer performance in the sprint tests.

The endomorphic component showed a negative correlation with standing long jump performance (r=-0.296; p<0.01), as well as a trend toward a negative relationship with cardiorespiratory capacity (Leger test; r=-0.174), which is consistent with existing knowledge about the limiting role of body fat on explosiveness and aerobic performance.

To determine the predictive value of the somatotype components on various indicators of physical fitness, a multiple linear regression analysis was performed using the Ordinary Least Squares (OLS) method. The independent variables in the models were the endomorphic, mesomorphic and ectomorphic components, while the dependent variables were the results of the tests for agility, strength endurance, explosiveness, speed, and aerobic capacity (Table 2).

Table 2. Regression results for different performance models

Dependent Variable	R2 Adj.	p-value	Independent variables	SC	p-value	Equation
Zig-zag test	0.079	0.021	Endo	0.291	0.012	Zig-zag test = 5.56 + 0.15 * Endo + 0.10 * Ecto
			Ecto	0.272	0.019	
Trunk lifts for 30 s	0.211	0.000	Meso	0.555	<0.001	MP30 = 15.48 + 2.06 * Meso + 1.20 * Ecto
			Ecto	0.300	0.002	
Standing long jump	0.108	0.001	Endo	-0.262	0.003	MSDM = 232.00 -4.74 * Endo -1.96 * Meso
			Meso	-0.147	0.092	
10 m sprint	0.217	0.000	Endo	0.237	0.027	TR10M = 1.58 + 0.04 * Endo + 0.07 * Ecto
			Ecto	0.538	<0.001	
20 m sprint	0.076	0.023	Endo	0.232	0.045	TR20M = 2.34 + 0.04 * Endo + 0.04 * Ecto
			Ecto	0.308	0.008	
30 m sprint	0.180	0.000	Endo	0.270	0.014	TR30M = 3.92 + 0.08 * Endo + 0.10 * Ecto
			Ecto	0.492	<0.001	
Leger test	0.069	0.012	Endo	-0.228	0.013	$V0_2$ = 47.84 - 1.20 * Endo + 0.78 * Meso
			Meso	0.205	0.025	

Note. R^2 Adj.: R^2 adjusted; SC: standardized coefficients; Endo: endomorphy; Meso: mesomorphy; Ecto: ectomorphy.

The model for agility (Zig-zag test) explained 7.9% of the variance (R^2adj=0.079; p=0.021). Both endomorphy (β=0.291; p=0.012) and ectomorphy (β=0.272; p=0.019) showed significant positive associations with the completion time, indicating their negative predictive role for agility performance. In the strength endurance of abdominal muscles, mesomorphy (β=0.555; p<0.001) and ectomorphy (β=0.300; p=0.002) emerged as significant positive predictors, with the model explaining 21.1% of the variance (R^2adj=0.211; p<0.001).

The model for the standing long jump test explained 10.8% of the variance (R^2adj=0.108; p=0.001), where endomorphy (β=-0.262; p=-0.003) showed a significant negative association with performance, consistent with its limiting influence on explosive strength. In the sprint tests, both endomorphy and ectomorphy emerged as positive predictors of running time over 10 m (R^2adj=0.217), 20 m (R^2adj=0.076), and 30 m (R^2adj=0.180), with statistically significant standardized coefficients (p<0.05 for all).

Finally, for the Leger test (maximal aerobic capacity), the model explained 6.9% of the variance (R^2adj=0.069; p=0.012), with endomorphy (β=0.228; p=0.013) and mesomorphy (β=0.205; p=0.025) identified as significant predictors, representing negative and positive associations with VO_2max values, respectively.

Discussion

Somatotype components: endomorphy (body fat), mesomorphy (muscle mass), and ectomorphy (leanness of structure) greatly determine the physical fitness of young athletes. This study observed these components in football players at the ages 13 to 15 and their influence on the short-distance running speed, lower extremities explosive strength, aerobic capacity (VO_2max), agility, and strength endurance of the abdominal muscles.

The present findings suggest that somatotype may represent an important morphological correlate of selected physical fitness characteristics in young male football players. Within the observed pattern, mesomorphy appeared to be the most favourable component, showing a more beneficial relationship with sprinting performance and abdominal muscular endurance. This may indicate that greater musculoskeletal development provides certain functional advantages in football-related tasks that depend on force production and repeated muscular effort. By contrast, ectomorphy was associated with less favourable sprint performance, while endomorphy showed an unfavourable relationship with explosive strength and aerobic fitness, suggesting that increased relative adiposity may limit efficiency in tasks requiring rapid body propulsion and sustained physiological effort. Although these findings should be interpreted with caution, particularly given the cross-sectional nature of the study, they nevertheless support the view that somatotype may contribute to the explanation of inter-individual differences in physical performance during adolescence. From an applied perspective, the results indicate that somatotype assessment may have value as a complementary tool in the monitoring of player development and the individualization of training in youth football. These findings may be more fully understood when considered alongside previous studies that have examined the relationship between body build, body composition, and football-specific performance in young athletes.

Previous studies report an influence by the somatotype on sports performance. Martínez-Mireles et al. (2025) note that mesomorphy is positively associated with sprint speed and greater power, while endomorphy is usually negatively correlated with high jump performance (Martínez-Mireles et al., 2025). On the other hand, mesomorphic and ectomorphic components usually better determine aerobic endurance (higher VO_2max) due to the low-fat content (Martínez-Mireles et al., 2025). Such physiological and biomechanical interactions can be explained through body composition: the increased muscle mass, characteristic of the mesomorphic type, which provides a larger cross-sectional area of the muscles for generating force and more favourable contractile properties (fast muscle fibre activity), which directly contributes to more explosive jumps and sprints. Contrariwise, a high percentage of body fat (endomorphy) doesn't contribute towards strength and serves as a passive (ballast) mass that increases inertia while running, while decreasing the body-mass ratio (Becerra-Patiño et al., 2025; Sivric et al., 2018). Lean physique, typical of the ectomorphic somatotype, can contribute to greater aerobic efficiency (higher VO_2max), on account of reduced body mass, which facilitates movement and allows for more efficient thermoregulation; however, it is usually associated with lower levels of absolute strength due to limited muscle mass.

Our results show that the mesomorphic somatotype predominates among the young football players studied. Players with high mesomorphy achieved significantly better results in the vertical jump test and better time results in the 30-meter sprint test compared to those with a higher endomorphic proportion (Cinarli et al., 2022). This finding is consistent with the known physiological mechanisms: increased muscle mass enables stronger muscle contractions and more favourable mechanical momentum, resulting in a higher strength-to-body-mass ratio and, thus a superior explosive performance.

Contrary to this, higher endomorphy observed in our study correlated with worse outcomes: greater body fat decreases the strength-to-body-mass ratio and limits speed and jump. As noted by other studies, a high adipose percentage is a limiting factor in young football players (Becerra-Patiño et al., 2025; Sivric et al., 2018). An inverse dependency is expected with regard to aerobic endurance (VO_2max): less fat and greater ectomorphy usually mean better VO_2max per kg. Martínez-Mireles et al. (2025) suggest that the mesomorphic and ectomorphic components may be associated with better aerobic endurance due to lower fat content. Although in football players endomorphy is directly associated with worse agility-ballistic results, i.e., agility and explosive strength complement each other; thus, dominantly mesomorphic players will potentially be more agile, while dominantly ectomorphic ones are more predisposed to long-term endurance.

These findings are supported by several international studies published in the past 5–10 years. For example, Kolena et al. (2024; Slovakia) found that the average somatotype of young football players is "ectomorphic mesomorph" and emphasize that the player's position in the team is often related to the somatotype and anthropometric factors (goalkeepers have significantly higher weight and muscle mass than other players playing in other positions). Along the same lines, Nobari et al. (2021; Portugal) report significant differences in the body composition and stamina parameters among players according to their position; they recommend that coaches monitor maturation-related factors (PHV) and bodily composition (BF, somatotype) for a more complete assessment when selecting talent. (Cinarli et al. 2022) directly confirmed that the dominant mesomorphic somatotype is associated with the best results in vertical jump and sprint tests, which supports our result on the importance of mesomorphy for explosive abilities. Becerra-Patiño et al. (2025) record similar findings in women's football; they demonstrate that increased muscle and bone mass (mesomorphy) closely correlate with better strength and speed indicators, while high adiposity reduces performance. Collectively, these studies from different countries support the idea that the optimal athletic morphology, moderate fat mass, and developed muscles significantly influence performance in sports where explosive movement and good endurance dominate.

When assessing the strengths and weaknesses of this study, several points can be made. One of the strengths is the use of well-established methodologies: standardized anthropometric measurements and Heath–Carter somatotype methods were applied, as well as a wide range of functional tests (jumps, sprints, aerobic capacity, and agility). However, the study is subject to certain limitations. The participant's sample is of a relatively small size as well as homogenous (players from a single country), which reduces the overall validity (Nobari et al., 2021). Cross-sectional studies prevent the establishment of causal relationships and do not track changes over time; this would require longitudinal studies. Additionally, all possible confounding factors were not equally controlled (for ex. the level of training, biological maturation), factors that significantly influence anthropometry in adolescents. Methodologically speaking, the scope of applied tests was limited (for example, horizontal jump tests or complex change-of-direction assessments), which could partly reduce the capacity of the analysis in the detection of subtle differences (Cinarli et al., 2022). However, despite these limitations, the results offer important insights and lay the foundation for future research with larger and more representative samples.

From a practical point of view, these findings provide specific recommendations for coaches and managers in youth football. First, regular profiling of the somatotype and composition components can help in adjusting personalised training programmes. Thus, players with a higher endomorphic component should be encouraged to practice activities aimed at reducing body fat and increasing muscular strength (for ex., strength training, HIIT), in order to improve the strength-to-body-mass ratio and improve sprinting performance. Mesomorphic players, on the other hand, should receive specialized explosive strength training (plyometrics, fast sprints, jump programs) to maximize their natural predispositions (Cinarli et al., 2022). When selecting talent, it is possible to consider somatotype as an additional criterium: balanced mesomorphy (moderate fat percentage and well-developed muscles) is frequently considered as an ideal profile as to what is required from a football player. A multi-factor monitoring approach is also recommended: combined growth-rate monitoring (PHV), estimated body-fat percentage and somatotype with fitness performance testing (VO_2max, sprinting and agility tests) (Nobari et al., 2021). These measurements will help coaches maximize the potential of young players by adapting programs to their biological maturity and physical composition. In summary, understanding how somatotype impacts performance allows for more precise training and selection, with the aim of developing successful footballers.

Conclusion

The results obtained clearly indicate that the somatotype is an important biological predictor of physical abilities in young footballers, although its influence is partial and intertwined with other factors. A balanced, athletic physique (with dominance of the muscle component and low level of subcutaneous adipose tissue) proved to be the most favourable for achieving high performance in speed, explosive power, endurance, and agility tests. These results are consistent with current scientific understanding and with the morphological profiles observed in successful athletes, confirming that body composition shouldn't be overlooked in selection and training processes. However, body type is not destiny; the trajectory of training and development, particularly in youth athletes, can significantly modify both body characteristics and performance. Coaches should therefore use somatotype information as a guiding tool, while maintaining focus on the comprehensive development of each athlete's skills and physical capacities. Combining an optimal body structure with targeted training and technical development is likely to yield the best performance outcomes, a conclusion that our study supports with empirical evidence.

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Conflicts of Interest
The authors declare no conflict of interest.

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