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Correlations Between Body Composition Indicators and Performance in Sprint and Agility Tests Among Handball Referees

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ABSTRACT. Introduction: Refereeing plays a decisive role in the development of handball games, as referees enforce the rules of the game and facilitate the functioning of the other components, essential to success. To remain consistently prepared, referees must maintain optimal physical condition to support both essential and complementary motor abilities. **Objectives:** This study aimed to investigate the correlations and regression models between body composition variables and performance in sprint and agility tests among handball referees. **Methods:** A sample of 12 referees underwent anthropometric assessments using bioelectrical impedance analysis (Tanita MC-580) to explore the correlations between body composition and performance in sprint and agility tests. Statistical analyses included correlation and regression tests to identify significant predictors. **Results:** The findings indicate a positive correlation between sprint speed and agility, and a negative correlation between sprint speed and bone mass. **Conclusions:** Despite the limited sample size, the findings suggest that fat-free mass (FFM) and fat mass (FM) influence referees' physical performance. Further research on larger samples is recommended to validate these results.

Keywords: *handball, referee, anthropometry, speed, agility.*

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INTRODUCTION

Handball is a professional and Olympic sport played by two teams of seven players (six field players and one goalkeeper) on a 40 × 20 m court (García-Sánchez et al., 2023). The game engages both aerobic and anaerobic thresholds, and an athlete's height and body composition may influence referees' physical performance. Handball involves periods of intense physiological exertion as well as phases of low activity (Lijewski et al., 2021; Hermassi et al., 2021). It is a full-body sport that demands high levels of speed, muscular strength, and flexibility (Haksever et al., 2020; Rios et al., 2023).

Modern handball is continuously evolving through player interactions and environmental influences (Espoz-Lazo & Hinojosa-Torres, 2025). Consequently, contemporary handball performance depends on various factors such as reaction time, movement time, decision-making ability, and body composition (Śliż et al., 2025; Arnaoutis et al., 2024).

Handball referees, as well as those in other sports (Sant'Anna et al., 2021), have multiple responsibilities during a match, which are significantly easier to fulfill when they are physically fit and not hindered by physical limitations (Belcic et al., 2022). In addition to the athletic aspect, physical preparedness enhances a referee's authority—an essential component for officiating, maintaining match control, and making difficult decisions with greater confidence and assertiveness (Belcic et al., 2022; Webb et al., 2024). Referees carry the critical responsibility of enforcing the rules of the game (Mazaheri et al., 2016).

Body composition is an important factor among referees. The structure of body mass provides insight into the content of the various components that make up the human body (Aniśko et al., 2024). Although no significant correlations have been found between refereeing quality and body composition (BMI and body fat percentage) (Belcic et al., 2022), it remains highly relevant, as it can influence referees' physical performance (Bustos-Viviescas et al., 2020).

The World Health Organization (WHO) encourages the use of Body Mass Index (BMI), as it is a simple and easy-to-calculate indicator. BMI is the most commonly used method for detecting excess weight and severe overweight (Galeas et al., 2017).

Also known as the Quetelet Index, BMI represents the ratio of body weight to height squared. It is used to determine the degree of obesity and is considered a cost-effective and quick method of assessment (Díaz, 2015, pp. 16–17; Alvarez, 2023, p. 16; Guamialamá-Martínez et al., 2018). However, BMI may not be entirely accurate for athletes, as results can vary due to their greater muscle mass.

The optimal range for adults, regardless of gender, is between 18.5 (minimum value) and 24.9 kg/m^2 (maximum acceptable value) (Guamialamá-Martínez et al., 2018). To better clarify optimal values in this study, we also calculated BF (Body Fat Mass) and FFM (Fat-Free Mass) to enhance the interpretation of the results obtained.

FFM represents the estimated mass of all molecules in the body that are not fat. It includes all non-lipid components, such as phospholipids from cell membranes and nervous tissue (Heymsfield et al., 2024).

Excess adipose tissue inhibits muscle activation, thereby limiting performance on the field. A leaner body produces greater power and sustains physical activity more efficiently (Lijewski et al., 2019). Body fat percentage is a more suitable indicator for performance evaluation in handball, and its results may be considered more relevant than BMI values (Hermassi et al., 2021).

I consider the analysis of body composition in handball referees essential for assessing bioimpedance levels in comparison with international-level referees, and for classifying the performance level of our referees relative to elite referees from other countries. The Tanita MC-580 analyzer provides a detailed assessment of numerous parameters, including body weight, BMI, body fat mass (BF), body fat percentage (BF%), bone mass (BM), muscle quality, muscle score, visceral fat, total body water percentage, basal metabolic rate (BMR), daily caloric intake, metabolic age, physique rating, and bone mass. Additionally, it offers a segmental analysis of fat percentage and muscle mass for each arm, leg, and trunk.

The Tanita body fat analyzer is an innovative device for estimating body fat based on the principles of bioelectrical impedance. Unlike other impedance systems that use surface electrodes, this device requires subjects to stand barefoot on a metal platform containing integrated electrodes, allowing impedance to be measured through the feet and the lower torso (Jebb et al., 2007).

STUDY OBJECTIVE

The primary objective of this study was to analyze the relationships between body composition indicators and performance in sprint and agility tests among a sample of handball referees. Using correlation and multiple regression methods, the study aimed to identify significant predictors of physical performance in order to better understand the impact of body characteristics on the specific physical demands of handball refereeing.

MATERIALS AND METHODS

To assess body composition parameters, the study included 12 handball referees - 10 males and 2 females - with a mean age of 25.67 ± 8.16 years and an average refereeing experience of 5.75 ± 5.69 years.

On October 30, 2024, at the Tomești Sports Hall in Iași County, Romania, motor and anthropometric testing were conducted during the evening hours between 7:00 PM and 10:00 PM. The sports hall was heated to an optimal temperature, similar to match conditions. Referees were instructed to refrain from engaging in any physical activity for 24 hours prior to testing, and on the day of testing, they abstained from their typical daily activities (e.g., going to work). Approval for testing was obtained from the Romanian Handball Federation and the Iași County Handball Association. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. All participants provided informed consent prior to participation.

For the sprint tests, distances relevant to handball gameplay were used - 10 meters and 30 meters - while agility was assessed using the 505-agility test. Using the Tanita MC-580 device, we measured BMI, visceral fat percentage, muscle mass percentage relative to body weight, bone index, and fat-free mass. Motor testing was conducted with the aid of Witty SEM by Microgate. This device, paired with a "smart indicator," is recommended for the accuracy and reliability of the results it provides.

The measurement procedure with the Tanita analyzer involved positioning the subjects on the platform in a perfectly upright and still posture for approximately 45 seconds, during which the device scanned and recorded all body composition data. For motor performance testing, using the Microgate system, subjects were positioned behind a starting line, in front of two laser gates equipped with light and motion sensors, connected at a 5-meter distance. These sensors acted as timing gates at the start line, at 10-meters, and at 30-meters. The subjects started at their own discretion - without a pre-set signal - when they felt ready, and were instructed to sprint through the three gates at maximum speed. For the agility test, the laser gates were arranged differently. Subjects ran at a self-selected pace to the first gate, sprinted 5 meters, executed a quick turnaround, and sprinted back another 5 meters. The Microgate system recorded the elapsed time between the initial crossing and the return through the starting gate. Each subject was allowed two attempts, and the best recorded time was selected for analysis. Table 1 presents the participants' age, height, gender, and weight.

Table 1. Anthropometric data of the subjects

Age	Weight	Gender	Height
25.67 ± 8.16	87.83 kg ± 15.84 kg	The sample consisted of 12 participants: 10 males and 2 females.	178.42 cm ± 6.19 cm

Based on the Pearson correlation analysis, we identified several significant relationships between certain motor and anthropometric variables over the 10-meter distance. However, simple correlations do not allow for the simultaneous evaluation of the combined effect of multiple factors. Therefore, to determine which anthropometric variables have an independently significant influence on 10-meter sprint performance, we applied multiple linear regression analysis. This approach provides a more comprehensive understanding of the factors influencing motor performance.

The normality of data distribution was tested using the Shapiro - Wilk test. The results indicated that all variables followed a normal distribution ($p > 0.05$), allowing for the use of parametric tests in the statistical analysis. The level of statistical significance was set at $p < 0.05$.

RESULTS

Table 2 presents the results obtained in the speed tests, specifically the 10-meter and 30-meter sprints performed by the subjects. Only the best performance time for each referee was recorded and reported.

Table 2. Referees' Results in the 10 Meter and 30 Meter Sprint Tests

Speed 10 m	Speed 30 m
1.83 m/s ± 0.15 m/s	4.64 m/s ± 0.43 m/s

Table 3 shows the referees' results in the agility tests, specifically the 505 agility test. As with the sprint tests, each referee had two attempts, and the best time was recorded in the table.

Table 3. Referees' Results in the Agility Test – 505 Agility Test

Agility 505 – Test
Subjects = 2.55 s ± 0.17 s

Table 4 presents the values for Body Mass Index (BMI), the percentage of muscle mass relative to body weight, and the percentage of fat-free mass.

Table 4. Results for BMI, FFM, and MM

BMI (Body Mass Index)	**FFM (Fat-Free Mass)**	**MM (Muscle Mass)**
27.53 kg/m² ± 4.64 kg/m²	65.6 kg ± 10.12 kg	62.34 kg ± 9.65 kg

Table 5 presents the subjects' results for visceral fat levels and bone mass index.

Table 5. Results for Visceral Fat Level and Bone Mass Index

Visceral Fat (level)	**Bone Mass**
6.83 ± 3.90	3.26 kg ± 0.48 kg

Table 6 presents the final measurements recorded for our subjects: fat mass and skeletal muscle mass.

Table 6. Referees' Results for Fat Mass (FM) and Skeletal Muscle Mass (SMM)

FM (Fat Mass)	**SMM (Skeletal Muscle Mass)**
22.25 kg ± 6.75 kg = 25.01% ± 3.63%	37.87 kg ± 7.31 kg = 44.32% ± 5.18%

The 10-meter sprint test was significantly and positively correlated with the 505 agility test ($r = 0.683$, $p = 0.014$), indicating that participants with higher sprint speed tended to demonstrate better agility performance.

Additionally, a significant negative correlation was observed between bone mass (BM) and the 10-meter sprint test, indicating that lower bone mass may be associated with greater speed over short distances. Although variables such as skeletal muscle mass and fat-free mass showed negative correlation trends with the motor tests, these values did not reach statistical significance. Table 7 presents the significant correlations observed in our study.

Table 7. Significant correlations between speed, agility and bone mass

Correlated variables	Correlation coefficient (r)	Statistical significance (p)	Correlation type
Speed 10 m - Agility test 505	0.683	0,014	Significantly positive
Speed 10 m - Bone mass	-0,578	0,049	Significantly negative

Linear Regression Results for the 10-Meter Sprint Test

Fat-Free Mass (FFM) and Fat Mass (FM)

Multiple linear regression analysis demonstrated that both fat-free mass (FFM) and fat mass (FM) are significant predictors of 10-meter sprint performance. The negative coefficient for FFM clearly indicates that an increase in fat-free mass is associated with a reduction in 10-meter sprint time, meaning it enhances maximum speed. Conversely, fat mass was shown to be positively associated with sprint time, suggesting that higher fat mass contributes to slower sprint performance over this distance.

Table 8. Linear Regression Analysis of FFM, FM, and BM on 10-Meter Sprint Performance

Predictor	Unstandardized Coefficient (B)	Standard Error (SE)	Standardized Coefficient (Beta)	t	p	VIF
Constant	2.392	0.224	-	10.695	<0.001	-
FFM	-0.018	0.006	-1.215	-3.184	0.011	2.795
FM	0.028	0.011	0.922	2.416	0.039	2.795

R^2 = 0.531, F (2,9) = 5.094, p = 0.033

Height, Weight, and BMI

Regarding the participants' weight, height, and BMI, the analysis revealed a positive and significant effect of weight on sprint performance (coefficient B = 0.264, p = 0.011), indicating that greater body weight was associated with higher sprint speed. In contrast, both height and BMI showed a negative effect on sprint performance (B = -0.249, p = 0.010 and B = -0.825, p = 0.010, respectively), suggesting that taller stature or a higher BMI were associated with slower sprint speeds over the 10-meter distance.

MM and SMM

According to the results, neither muscle mass (MM) nor skeletal muscle mass (SMM) had a significant effect on sprint speed, as indicated by p-values greater than 0.05. Additionally, the collinearity indicators (VIF) were below the critical threshold, indicating no major multicollinearity issues among the explanatory variables.

BM

Visceral fat was analyzed separately from the other body composition variables, as it was measured in discrete levels rather than percentages or kilograms, making it incompatible for direct inclusion in regression models alongside continuous variables.

Bone mass was also treated independently, since it showed a significant and strong correlation with 10-meter sprint speed in the Pearson correlation analysis, thereby justifying the investigation of its standalone effect on sprint performance.

Bone mass appears to be an important factor in 10-meter sprint performance. As bone mass increases, the time required to complete the sprint tends to increase (see Table 9).

Table 9. Linear Regression of Bone Mass (BM) on 10 Meter Sprint Performance

Predictor	Unstandardized Coefficient (B)	Standard Error (SE)	Standardized Coefficient (Beta)	t	p	VIF
Constant	2.418	0.264	-	9.162	<0.001	-
BM	-0.179	0.080	-0.578	2.237	0.049	1.000

R^2 = 0.334, F (1,10) = 5.006, p = 0.049

Visceral Fat

The results from the multiple regression analysis suggest that visceral fat is not a major predictor of 10-meter sprint performance. Other variables appear to play a more significant role in determining sprint ability. While visceral fat is often linked to metabolic risk factors, it does not seem to have a relevant impact on short-distance sprint performance.

Linear Regression Results for the 30-Meter Sprint Test

FFM and FM

The results indicate the very weak influence of both fat-free mass (FFM) and fat mass (FM) on 30-meter sprint performance. Although FFM showed a near-significant coefficient ($p = 0.054$), suggesting that greater fat-free mass tends to reduce sprint time, the results are not sufficiently strong to be considered statistically relevant.

Height, Weight, and BMI

Regarding the 30-meter sprint performance, relevant findings were identified. Height showed a negative influence within our sample, indicating that taller participants performed worse in the 30-meter sprint test ($B = -0.952$, $p = 0.006$). Similarly to the 10-meter sprint, a higher BMI was also associated with poorer performance. A surprising result in our study was that referees with greater body weight achieved better sprint outcomes. This may be explained by their higher proportion of muscle mass ($B = 1.011$, $p = 0.006$).

MM and SMM

As with the 10-meter sprint, the multiple regression model for 30-meter sprint speed showed that both muscle mass (MM) and skeletal muscle mass (SMM) were not significant predictors. In their measured form, neither variable directly influenced sprint capacity in this sample.

BM

The negative coefficient for bone mass ($B = – 0.431$) suggests that higher bone mass is associated with lower sprint times over 30 meters (i.e., greater speed). However, this effect was not statistically significant ($p = 0.196$).

Visceral Fat

The coefficient for visceral fat was also negative (B = –0.010), indicating a very weak and non-significant relationship between visceral fat levels and 30-meter sprint performance.

Linear Regression Results for the Agility Test – 505-Agility Test

FFM and FM

Table 10 provides a significant representation of the predictors FFM and FM. Our model shows that approximately 43.7% of the variation in agility test performance is explained by these variables, indicating a moderate to strong relationship between body composition and agility test scores.

Table 10. Linear Regression of FMM and FM on 505-Agility test

Variable	Coefficient B	Standard Error	Standardized Beta	t	p
(Const.)	2,988	0,288	—	10,382	0,000
FFM	–0,019	0,007	–1,079	–2,581	0,030
FM	0,036	0,015	1,007	2,407	0,039

Participants with greater muscle mass tended to achieve better (lower) times, indicating superior agility. Fat mass (FM) had a positive and statistically significant influence on performance time (p = 0.039), suggesting that a higher proportion of body fat is associated with poorer agility performance.

Height, Weight, and BMI

None of the predictors showed a statistically significant contribution. The negative coefficient for BMI suggests a trend indicating that performance may be poorer with higher BMI; however, this result is not statistically meaningful in this sample.

MM and SMM

In this sample and under these conditions, muscle mass (MM) and skeletal muscle mass (SMM) do not appear to be relevant predictors of performance in the 505-agility test. The results indicate no significant findings.

BM

According to the data obtained, bone mass does not significantly influence performance in the agility test.

Visceral Fat

Visceral fat does not have a significant effect on performance in the 505-agility test ($R = 0.09$, $p = 0.78$), explaining only 0.8% of the variance. The regression coefficient is non-significant (–0.004), indicating no meaningful relationship between the two variables.

DISCUSSION

Although our methodology included correlation and regression analyses, the results will be discussed in relation to the existing body of literature, which generally explores the relationship between body composition and physical performance.

Our findings show that the regression analyses identified weight, height, and BMI as the most significant predictors of 30-meter sprint performance, explaining 66.7% of the variation in results. The positive coefficient for weight indicates that, within this sample, heavier participants achieved better sprint times—possibly due to greater muscle mass.

FFM and FM showed moderate influence on agility test performance and the 10-meter sprint. Although recent studies suggest that handball referees do not spend much time in the anaerobic zone, it is important to note that the most critical decisions are often made at that level of exertion (Belcic, 2022; Babity, 2022). Hermassi (2021) emphasizes that body fat percentage is a more accurate metric for assessing handball performance than BMI. He analyzes the impact of body fat on agility testing and concludes that higher fat mass increases the predictive power of regression models in athletes.

Our results indicate that higher muscle mass contributes positively to improved sprint and agility times, while fat mass has a detrimental effect. In the 10-meter test, bone mass (BM) was negatively correlated with performance: the lower the bone mass in kilograms, the better the sprint performance. This suggests that less skeletal mass may reduce inertia during acceleration and improve short-distance speed.

The sprint performance findings in our sample are consistent with those reported in recent studies. Šegota (2024) analyzed 32 referees from Croatia and reported average sprint speeds at various distances. The average time for international referees was 1.80 ± 0.12 seconds, and for national referees, 1.94 ±

0.15 seconds. These are comparable to our findings, with our sample showing an average of 1.83 ± 0.15 seconds.

The referees' average body weight (87.83 kg ± 16.49 kg) was consistent with findings in other studies. FFM (20.45 ± 2.84 kg/m^2) and body fat (22.25 kg ± 7.05 kg) were also similar to values reported by other researchers (Babity, 2022; Belcic, 2022; Fernandes da Silva, 2010; Martínez-Rodríguez, 2024).

A significant correlation was observed between the 10-meter sprint and the 505 agility test, indicating a strong link between the two motor qualities. Referees who performed well in the sprint also achieved better agility scores. Additionally, a significant negative correlation was found between 10-meter sprint speed and bone mass, suggesting that higher bone mass may increase inertia and negatively affect short-distance acceleration.

One of the main limitations of this study is the small sample size, which may affect the statistical power and generalizability of the findings. To confirm and expand upon these results, further research is needed with a larger and more diverse sample. Nevertheless, this topic remains important and relevant for future research, given its potential contribution to understanding the relationship between body composition and physical performance in handball referees.

CONCLUSIONS

The results of this study highlighted the influence of body composition on motor performance in both agility and sprint tests over various distances. The most important predictors were fat-free mass (FFM) and fat mass (FM), both of which influenced motor performance variables.

A significant negative correlation was also observed between 10-meter sprint speed and bone mass (BM), suggesting that lower bone mass may positively affect sprint capacity. These findings suggest that higher levels of muscle mass may enhance sprint performance in handball referees, as referees with greater muscle mass tended to achieve better sprint performance, likely due to increased muscle development.

While the small sample size limits the generalizability of the results, the study provides a strong rationale for further research with a larger and more diverse sample. As the first study of its kind in Romania, it underscores the need to explore the role of referees in greater detail, given their potential impact on performance and decision-making in high-intensity moments of handball matches.

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