Relationship between physical performance and body composition in semi-professional soccer players

Relación entre desempeño físico y composición corporal en futbolistas semiprofesionales

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Abstract

Introduction: Soccer is a high-intensity sport that involves movements such as jumps, sprints, changes of direction, and other dynamic actions, which require optimal physical development, including explosive strength and an adequate balance of body composition, both of which are essential to meet competitive demands.
Objective: To analyze the relationship between physical performance and body composition in semi-professional soccer players.
Methodology: A total of 20 players were evaluated (age: 19.03 ± 0.8 years, weight: 71.36 ± 6.8 kg, height: 174.12 ± 6.4 cm). Explosive strength was assessed through squat jump height and countermovement jump. Body composition was determined using the ISAK anthropometric method. Agility was measured with the Illinois agility test and the T-test, and acceleration was assessed over a 30-meter sprint.
Results: Significant correlations were observed between the fat component and agility (r = .681**, p = .001). Negative relationships were also found between explosive strength and agility, as measured by the Illinois test (r = -.542*, p = .013; r = -.478*, p = .033, respectively).
Discussion: The findings confirm that fat mass negatively affects physical performance and emphasize the importance of explosive strength training in this type of sport to enhance different types of movement. Additionally, the role of jump training in optimizing horizontal displacements is highlighted.
Conclusions: A direct relationship between physical performance and body composition is confirmed, indicating that the development of specific physical capacities should be combined with the optimization of body characteristics to maximize competitive performance.

Keywords

Agility; soccer; fat percentage; jump; sprint.

Resumen

Introducción: El fútbol es un deporte de alta intensidad, que implica movimientos como saltos, sprints, cambios de dirección y otras acciones dinámicas, las cuales requieren un óptimo desarrollo físico incluyendo la fuerza explosiva y un adecuado balance de la composición corporal, los cuales son fundamentales para responder las demandas competitivas.
Objetivo: Analizar la relación entre desempeño físico y composición corporal en futbolistas semiprofesionales. Metodología: Se evaluaron 20 jugadores (edad: 19.03 ± 0.8 años, peso: 71.36 ± 6.8 kg, talla: 174.12 ± 6.4 cm), se evaluó la FE a través de la altura del salto squat jump y el salto en contramovimiento, la composición corporal se obtuvo por medio del método antropométrico ISAK, la agilidad a través del test de Illinois y el T-test, y por último la aceleración en 30 m lanzados.
Resultados: se hallaron correlaciones entre el componente graso y la agilidad .681** (p=.001) y relaciones negativas entre la fuerza explosiva y la agilidad medida con el test de Illinois -.542* (p=.013), -.478* (p=.033) respectivamente.
Discusión: Se reitera cómo el componente graso afecta el desempeño físico y se destaca la importancia del entrenamiento de la fuerza explosiva en este tipo de deportes para asumir los diferentes tipos de desplazamientos, así como la importancia del entrenamiento a partir de los saltos para optimizar desplazamientos horizontales.
Conclusiones: Se confirma la existencia de una relación directa entre el desempeño físico y la composición corporal, lo que implica que se debe combinar el desarrollo de las capacidades físicas específicas con la optimización de las características corporales para maximizar el desempeño competitivo.

Palabras clave

Agilidad; fútbol; porcentaje graso; salto; sprint.

Introduction

Soccer is a high-intensity sport that involves movements such as jumps, sprints, changes of direction, and other dynamic actions (Domingues et al., 2024; Sánchez-Abselam et al., 2024). Although research has indicated that low-intensity actions are the most frequent during a match, it has been identified that high-intensity actions, which occur between 10% and 20% of the game time (Morera-Barrantes et al., 2021), are the ones that determine the outcome of a match. These actions, often explosive, largely depend on strength and speed, factors that are closely related to the power and explosiveness required in soccer.

The importance of monitoring and tracking body composition in cooperative-opposition sports is undeniable, especially in those where height and composition can provide competitive advantages. However, this relevance is less evident in sports where there is significant physical variability within the same team (Campa et al., 2021; Lukaski & Raymond-Pope, 2021). In soccer, success is measured by a team's ability to score more goals than its opponent, requiring players to function as a cohesive and efficient unit. Assessing individual physical performance within the context of a team and understanding how each player contributes to the collective effort represents a significant challenge for sports scientists. It is crucial to have tests that can predict player performance in practical situations (Reilly, 2001). Maintaining an optimal body composition—characterized by a lower fat percentage and adequate muscle mass—is essential for enhancing physical performance in soccer. Excess body fat has been associated with reduced acceleration, lower jumping ability, and higher energy expenditure, while greater muscle mass contributes to improved strength, sprinting capacity, and agility. These components directly impact high-intensity actions such as sprints, directional changes, and jumps, which are decisive in competitive match situations (García-Chaves et al., 2023).

Body composition and physical capacities of athletes provide valuable information for improving performance and adjusting training (Guerrero Sánchez & Acosta Tova, 2019). Anthropometric and physical capacity assessments are essential for understanding and optimizing sports performance (Corredor-Serrano et al., 2024). However, these data must be carefully interpreted, considering the specific context of each sport and the characteristics of the evaluated population.

Each sport has unique physical demands and different anthropometric profiles. In soccer, body composition assessment can be crucial for determining training load, considering factors such as muscle mass values, body fat percentage, and bone maturation. Additionally, a player's specific position influences the physical demands they face, requiring a personalized approach to training (Keiner et al., 2021). Therefore, the objective of this research is to analyze the relationship between physical performance and body composition in semi-professional soccer players, highlighting the relevance of these variables in the sports preparation process.

Method

This study is correlational in nature, with a quantitative approach and a cross-sectional scope.

Participants

A total of 20 soccer players were evaluated (age: 19.03 ± 0.8 years, weight: 71.36 ± 6.8 kg, height: 174.12 ± 6.4 cm), selected through non-probabilistic convenience sampling. All participants were part of the semi-professional division of a professional soccer team in Colombia. The inclusion criteria required that players had no osteomuscular injuries in the lower limbs during the six months before testing and were actively engaged in the training process. Before the study began, approval was obtained from the club's management and the head coach of the category. Additionally, all players were informed about the objectives, procedures, risks, and benefits of the research. They voluntarily agreed to participate in the study by signing an informed consent form. The study complied with the ethical standards established in the Declaration of Helsinki (updated in 2013, Fortaleza, Brazil) and Colombian regulations, including Resolution No. 008430 of 1993 from the Ministry of Health and Social Protection on health research and Law 1581 of 2012 on personal data protection. The entire process was approved by the Ethics Committee of the National School of Sport University Institution in Cali, Colombia, under record 40.07.216, dated November 17, 2023.

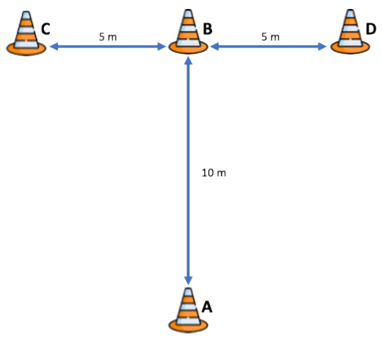
Procedure and Instruments

General data were recorded, including name, age, and various anthropometric measurements: Height was measured using a Seca 213 portable stadiometer (60–200 cm; accuracy: 1 mm), weight with a Terrallon Fitness Coach Premium scale (0–160 kg; accuracy: 100 g), circumferences with a Lufkin W606PM measuring tape (0–200 cm; accuracy: 1 mm), skinfolds with a Slim Guide caliper (0–75 mm; accuracy: 0.5 mm), and finally, bone diameters with a Cescorf short anthropometer (16 cm) (0–164 mm; accuracy: 1 mm). For data collection, a designated space with controlled temperature and appropriate lighting was used. Based on the anthropometric parameters required for determining body composition and somatotype according to the International Society for the Advancement of Kinanthropometry (ISAK), a Level II-certified evaluator with an intra-observer technical error of 5.0% for skinfolds and 1.0% for circumferences and diameters (Stewart et al., 2011) conducted the measurements. After verifying the calibration of the instruments, the following measurements corresponding to the restricted profile were taken: height, weight, eight skinfolds (triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, thigh, and calf), seven body circumferences (relaxed arm, flexed arm, waist, hip, forearm, mid-thigh, and calf), and three bone diameters (humerus, femur, and bistyloid). Body composition was determined through the assessment of muscle mass, bone mass, and body fat percentage, following the guidelines of the Consensus Document of the Spanish Group of Kinanthropometry (GREC) of the Spanish Federation of Sports Medicine (Alvero et al., 2009). Muscle mass was calculated using the formula proposed by Lee et al. (2000), bone mass was estimated using Rocha's equation (1975), and body fat percentage was calculated using the Faulkner method (1958). Additionally, the sum of 4, 6, and 8 skinfolds was reported to support the descriptive analysis of subcutaneous adiposity.

The measurement of explosive strength was carried out using the Wheeler Jump photoelectric sensor by Wheeler Technology (Colombia), a wireless, portable, and lightweight system that allows for the evaluation of vertical jump height by estimating flight time (Patiño-Palma et al., 2022; Wheeler Botero et al., 2023a). Two jump modalities were used for assessment: the Squat Jump (SJ) and the Countermovement Jump (CMJ). For the Squat Jump (SJ), participants started from a static position with approximately 90 degrees of knee flexion, held isometrically for five seconds. From this position, they performed a maximal vertical jump without any preliminary downward movement, with hands placed on the hips to eliminate the influence of arm swing. For the Countermovement Jump (CMJ), participants began in an upright standing posture with feet shoulder-width apart and hands placed on the hips. They then performed a rapid eccentric–concentric movement consisting of a controlled downward phase followed immediately by a vertical jump executed at maximal effort. Three trials were completed for each jump type, with one-minute rest intervals between attempts. The highest jump height recorded was used for statistical analysis (Manrique Lenis et al., 2024; Moran et al., 2017).

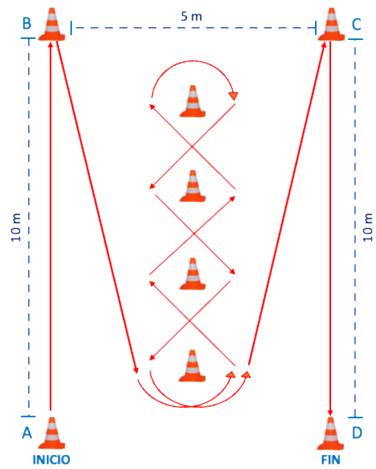
For agility assessment, the T-test was administered following the protocol by Raya et al. (2013), using a 10×10 m setup in which standardized movement patterns had to be executed in the shortest possible time. Timing was recorded with a Casio HS-70W-1DF stopwatch (Japan). Figure 1 illustrates the movement sequence: the athlete starts at cone "A" and moves forward to cone "B" upon the whistle signal. The athlete then performs lateral movement to cone "C" while maintaining frontal orientation and avoiding crossover steps, immediately changes direction, and moves laterally to cone "D" under the same conditions. Finally, the athlete changes direction again, returns to cone "B," and runs backward—without hip rotation—until crossing the finish line at cone "A".

Figure 1. T-test



Similarly, the Illinois agility test was administered both with and without the ball. The test area consisted of a 10-meter-long by 5-meter-wide rectangle, with a cone placed at each corner. A central row of four additional cones, spaced 3.3 meters apart, was placed lengthwise down the middle of the rectangle (Figure 2). In the version without the ball, the player started in a prone position with elbows flexed and hands aligned at shoulder level (plank position), and during the execution had to touch cones B and C with their hands. In the version with the ball, the player completed the course while maintaining continuous ball control, ensuring technical execution during high-speed displacements. In both cases, maximum speed and agility were required, and the best time from two attempts was recorded (Raya et al., 2013; Rúa-Posada et al., 2024).

Figure 2. llinois Test



To measure acceleration, the 30-meter flying sprint test was used. The test was conducted on a flat, straight surface, with the subject starting from a standing position. Three attempts were performed, and the best recorded time was taken using a Casio stopwatch (Japan), model HS-70W-1DF (Naclerio et al., 2007).

Warm-up

To prepare the participants for the tests, a warm-up was conducted consisting of joint mobility exercises, dynamic stretching, and running drills such as skipping, heel kicks, Russian skipping, and high knee raises. Additionally, acceleration drills over distances of 5, 10, 20, and 30 meters were performed, along with ball movement exercises to activate coordination and specific characteristics. Lastly, six simulated jumps of each type (SJ and CMJ) were executed in four rounds to properly prepare the body. It is important to highlight that both the warm-up and the physical evaluations were carried out on the same training field to maintain the surface's specific characteristics and allow the players to recognize their own training and competition space.

Data Analysis

The collected information was consolidated into a spreadsheet using Microsoft Excel, and data analysis was conducted using SPSS software (IBM Corporation, USA), version 26.0 for MAC. The normality of the data was verified using the Shapiro-Wilk test, and the relationship between variables was determined through Pearson correlation analysis with a significance level of $p > .05$.

Results

In Table 1, the descriptive data obtained for body composition and physical performance variables are presented. It is highlighted that the studied population has an average height of 174.12 cm and an average weight of 71.36 kg. Regarding the body mass index (BMI), a mean of 22.72 kg/m^2 was obtained, suggesting that the population falls within normal BMI ranges (López et al., 2022). Concerning body fat percentage, the average value found was 11.30%. In terms of muscle mass, the mean was 40.61 kg and 56.91%. Regarding physical performance, the mean value for the SJ jump was 38.35 cm, for the CMJ jump 41.10 cm, and for the T-test, 9.78 seconds.

Table 1. Body Composition and Physical Performance Characteristics (n=20)

Variable	Mean	(SD)	CI 95%		Sig.
Height (cm)	174.12	6.4	174.12	180.15	.745
Weight (kg)	71.36	6.8	68.19	74.52	.074
BMI (Kg/m2)	22.72	1.5	22.04	23.40	.694
Muscle Mass (kg)	40.61	4.0	38.75	42.48	.091
Muscle Mass Percentage (%)	56.91	4.6	56.83	56.99	.085
Bone Mass (kg)	12.31	1.4	11.67	12.95	.243
Body Fat Percentage (%)	11.30	1.3	10.66	11.93	.946
∑ 4 Skinfolds (mm)	36.03	8.8	31.91	40.15	.315
∑ 6 Skinfolds (mm)	51.58	11.3	46.28	56.88	.568
∑ 8 Skinfolds (mm)	67.18	15.0	60.17	74.19	.431
SJ Height (cm)	38.25	4.07	36.35	40.16	.091
CMJ Height (cm)	41.10	4.35	39.06	43.14	.640
Illinois without Ball (sec)	15.35	0.33	15.20	15.50	.589
Illinois with Ball (sec)	18.93	1.39	18.28	19.58	.104
T-test (seg)	9.78	.31	9.63	9.92	.604
30m Sprint Speed (sec)	3.63	.08	3.59	3.67	.662

SD: Standard Deviation; CI: Confidence Interval for the Mean; Sig.: Shapiro-Wilk Normality Test p<.05

In Table 2, the relationships between body composition and agility tests are presented, where the fat component, in all its expressions—whether by percentage or sum—shows a significant direct correlation with agility measured by the Illinois test without the ball. This implies that a higher presence of body fat results in a longer execution time in the Illinois test, thereby negatively affecting the player's physical performance.

Table 2. Relationship between body composition and agility

	T-test	Illinois without Ball
Height		.469* (p=.037)
Weight	.446* (p=.049)	
Body Fat Percentage		.681** (p=.001)
∑ 4 Skinfolds		.681** (p=.001)
∑ 6 Skinfolds		.612** (p=.004)
∑ 8 Skinfolds		.632** (p=.003)

*Significant correlation p<.05; ** Significant correlation p<.01.

In Table 3, the relationships between explosive strength values expressed in jump height and agility are presented, showing a significant and inversely proportional correlation. This means that greater jump height in these types of jumps corresponds to shorter execution times in the Illinois test, highlighting the direct relationship between explosive strength and agility in this sport.

Table 3. Relationship between explosive strength and agility

	Illinois without Ball
SJ Height	-.542* (p=.013)
CMJ Height	-.478* (p=.033)

* Significant correlation p<.05

Although the main findings focused on significant correlations, additional analyses were conducted to explore the relationships between fat mass and jump performance (SJ and CMJ), muscle mass and jump performance, and muscle mass and agility tests. However, these analyses did not yield statistically significant results (p > .05), and therefore, the data are not shown in the tables.

Discussion

The primary objective of this study was to analyze the relationship between physical performance and body composition in semi-professional football players. The results confirmed a significant association between fat mass and agility, and between explosive strength and agility, highlighting how specific body composition components influence performance in key football-related actions. These findings emphasize the importance of monitoring anthropometric variables as part of the athlete development process.

The results regarding body composition variables (Table 1) indicated that the players had an average height of 174.12 cm and weight of 71.36 kg. Compared to international studies conducted in Paraguay, Mexico, Spain, and Germany, participants were slightly shorter, while weight values were similar or higher (Ceballos-Gurrola et al., 2020; Keiner et al., 2021; Martínez-Sanz et al., 2011; Villagra Collar et al., 2023). The variability in these measurements can be attributed to factors such as playing position, age, competitive level, genetics, and training duration (Leão et al., 2022; Toselli et al., 2022; Falces-Prieto et al., 2024). The average body fat percentage (11.30%) was lower than in studies from Paraguay and Spain, while muscle mass (40.61 kg) was also comparatively lower than in U-22 Peruvian players (Robles Pino et al., 2019). These values reinforce the importance of monitoring body composition throughout athletic development, given that higher fat mass is associated with decreased force production and efficiency, while muscle mass relates to playing positions with higher physical demands (Conde-Pipo et al., 2023; Staśkiewicz et al., 2022; Staśkiewicz-Bartecka et al., 2023).

Explosive strength values, assessed through Squat Jump (SJ) and Countermovement Jump (CMJ), exceeded those reported in previous studies from Chile, Colombia, and Germany (Guerrero Sánchez & Acosta Tova, 2019; Keiner et al., 2021; Sáez-Michea et al., 2023). Jumping is a key action in football and is associated with neuromuscular power and the force-velocity profile (Wheeler Botero et al., 2023). Monitoring jump performance is crucial in strength programming as it reflects readiness for high-intensity match actions (Morera-Barrantes et al., 2021).

Agility performance, evaluated using the Illinois and T-tests, showed some variability when compared with international data. Studies in Paraguay and Turkey reported higher values (Muniroglu & Subak, 2018; Villagra Collar et al., 2023), whereas those from Germany and Mexico reflected similar or lower results (Ceballos-Gurrola et al., 2020; Keiner et al., 2021). A valuable contribution of this study was the inclusion of the Illinois test with ball control, which is less commonly reported and adds ecological validity to the assessment (Rúa-Posada et al., 2024).

Statistical analysis showed significant inverse correlations between SJ and CMJ heights and agility times, supporting the idea that higher explosive strength contributes to better agility performance (Teixeira et al., 2022; García-Chaves et al., 2023). These types of displacements are key in football and often occur under contextual constraints. Although no significant correlations were found between muscle mass and agility or jump performance, these analyses were conducted and should be interpreted cautiously. The lack of significance may stem from sample size limitations and interindividual variability. Future research should consider larger samples and the inclusion of variables like Rate of Force Development (RFD) (Oleksy et al., 2024).

Previous studies have proposed that explosive strength measured by jumps is also linked to sprinting performance (Madroñero et al., 2023; García-Chaves et al., 2023), though this relationship may be inconsistent (Oleksy et al., 2024). Additionally, the stretch-shortening cycle involved in jump mechanics has been shown to impact agility and sprinting, as reported in studies by Gómez-Álvarez et al., (2019), Ramírez-Campillo et al., (2018), and Faria et al., (2021). While strength and plyometric training can optimize these abilities (Izquierdo et al., 2018; Ramírez-Campillo et al., 2019), their relevance in this study is secondary to the central focus on performance-body composition relationships.

In conclusion, the findings confirm that morphological variables, especially fat mass, significantly influence physical performance in football-specific tasks. Although muscle mass did not show significant direct associations, its role cannot be dismissed. The integration of physical performance assessments with anthropometric monitoring is essential in the preparation process. Moreover, incorporating context-relevant evaluations, such as agility tests with ball control, enhances the applicability of findings to real-game conditions.

This study presents some methodological limitations that should be acknowledged. First, the skinfold measurements were performed using a Slim Guide caliper, which, although suitable for routine assessments in athletes (Esparza-Ros et al., 2022), may lack the precision of research-grade instruments such as the Harpenden caliper. This may affect the accuracy and comparability of the body composition data with other studies. Second, the sprint and agility test times were measured using a manual stopwatch.

Although validity and reliability have been demonstrated based on the coach's experience and the complexity of the test (Mirković et al., 2022), this method is still subject to limitations due to systematic errors and human reaction time. The use of more precise instruments, such as photoelectric timing systems, is recommended for future studies to enhance measurement reliability.

Conclusions

It is concluded that the evaluated soccer players exhibit adequate levels of explosive strength and agility, in some cases surpassing national and international benchmarks. Furthermore, the existence of a direct relationship between body composition and physical performance was confirmed, highlighting the importance of a comprehensive approach to physical preparation. Additionally, the inclusion of tests that facilitate the analysis of physical performance for both youth and professional athletes is emphasized. This approach should combine the development of specific physical capacities with the optimization of body characteristics to maximize the players' competitive performance.

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