RBNE
Revista Brasileira de Nutrição Esportiva

INFLUENCE OF BODY COMPOSITION AND PHYSICAL PERFORMANCE IN HIGHL Y TRAINED FEMALE FOOTBALL PLAYERS

Alberto Roso-Moliner[1], Oliver Gonzalo-Skok[2], Rafael Albalad-Aiguabella[1], Chris Bishop[3]
Demetrio Lozano[1], Elena Mainer-Pardos[1]

ABSTRACT

Introduction: Body composition plays a critical role in athletic performance, influencing strength, speed, and power outputs essential for competitive success. However, limited evidence exists on its relationship with specific performance measures in female football players. Objective: This study aimed to analyze the influence of body composition variables on key performance measures, including jumping ability, sprint speed, and change of direction (COD) in highly trained female football players. Material and methods: Thirty-eight players from the Spanish Women's Second Division participated in a cross-sectional study. Body composition was assessed via standardized anthropometry, and performance tests included countermovement jumps, horizontal jumps, 40-m sprints, and the 505 COD test. Results: Significant correlations were found between body composition and sprinting performance. Body fat percentage (r = -0.47 to 0.46, p<0.05) was negatively associated with sprint times, whereas higher skeletal muscle mass and fat-free mass were linked to better sprint and jumping performance. No significant relationships were found between body composition and COD performance. Players with lower body fat exhibited significantly better performance in horizontal jumps, 20-m, 30-m, and 40-m sprints, and peak velocity (ES: -0.78 to 0.68). Players with higher skeletal muscle mass performed better in the 10-m sprint (p<0.05, ES: 0.56), while those with higher fat-free mass demonstrated superior sprinting and jumping abilities. Conclusion: These findings highlight the importance of optimizing body composition for performance. Coaches should consider individualized training and nutritional strategies to improve muscle mass while reducing excess fat.

Key words: Team sports. Women. Kinanthropometry. Sprint performance. Jumping ability.

RESUMO

Influência da composição corporal e do desempenho físico em jogadoras de futebol altamente treinadas

Introdução: A composição corporal é determinante no desempenho esportivo, influenciando força, velocidade e potência. Contudo, poucos estudos analisaram essa relação em jogadoras de futebol. Objetivos: Investigar a influência das variáveis de composição corporal na capacidade de salto, velocidade de sprint e mudança de direção (COD) em jogadoras altamente treinadas. Materiais e Métodos: Participaram 38 atletas da Segunda Divisão Espanhola, em um estudo transversal. A composição corporal foi avaliada por antropometria padronizada. Os testes incluíram saltos verticais (countermovement jump), horizontais, sprints de 40 m e o teste 505 de COD. Resultados: Encontraram-se correlações significativas entre composição corporal e desempenho nos sprints. A porcentagem de gordura corporal (r = -0,47 a 0,46, p<0,05) correlacionou-se negativamente com os tempos, enquanto maior massa muscular esquelética e massa livre de gordura associaram-se a melhor desempenho em sprints e saltos. Não houve relação significativa com COD. Jogadoras com menor percentual de gordura mostraram desempenho superior nos saltos horizontais, sprints de 20 m, 30 m, 40 m e velocidade máxima (ES: -0,78 a 0,68). Atletas com mais massa muscular tiveram melhor resultado no sprint de 10 m (p<0,05, ES: 0,56). Conclusões: Otimizar a composição corporal, aumentando massa muscular e reduzindo gordura excessiva, é fundamental para aprimorar sprints e saltos. Treinadores devem adotar estratégias individualizadas de treino e nutrição para alcançar tais melhorias.

Palavras-chave: Esporte coletivo. Mulheres. Cinantropometria. Desempenho em sprint. Capacidade de salto.

1 - Health Sciences Faculty, Universidad San Jorge, Villanueva de Gállego, Zaragoza, Spain.

2 - Department of Communication and Education, Universidad Loyola Andalucía, Seville, Spain.

RBNE
Revista Brasileira de Nutrição Esportiva

INTRODUCTION

Football is possibly the most popular team sport today. However, there are still notable differences in popularity between women's and men's football (FIFA, 2007).

To address these disparities and ensure the continued growth of women's football, FIFA introduced the 'Women's Football Strategy' in 2020 (FIFA, 2020). One of its primary objectives is to double the number of female players by 2026 (FIFA, 2020).

Additionally, the strategy focuses on enhancing the women's school football program and improving coordination between federations, leagues, and clubs (FIFA, 2020).

To analyze the performance factors associated with women's football, examining the physical demands during competitive moments is essential.

Studies by Andersson et al., (2010) and Krustrup et al., (2010), conducted on elite female football, show that the average heart rate during matches ranges between 84-86% of maximum heart rate. Additional research indicates that the total distances covered during matches vary from ~8,500-12,000 m (Krustrup et al., 2010; Lago-Peñas et al., 2011; Wehbe et al., 2014).

These findings, combined with the 90-minute match duration, underscore the importance of endurance (aerobic capacity) as a performance factor in the sport (Mohr et al., 2003).

However, other, more decisive factors in matches influence key moments of the game and ultimately determine the outcome.

These are associated with anaerobic activities such as sprinting, jumping, and changes of direction (COD), as well as other actions that directly or indirectly impact these activities (Aziz et al., 2000; Little, Williams, 2007). All these critical actions involve variations in intensity and/or speed during the game.

For instance, Andersson et al., (2010) observed that an average of 1,641 ±41 actions involving intensity changes occur in women's football matches. Of these, 239 ± 30 are high-intensity runs (≥18 km/h), and 27 ± 4 are maximal sprints (≥25 km/h), covering total distances of 1,530 m ± 0.1 and 256 m ± 57, respectively.

Thus, optimizing high-intensity activities for female football players seems to be one of the key factors in achieving success.

In terms of body composition, factors such as optimal muscle mass (associated with greater strength and power) and lower fat mass (resulting in a better strength-to-weight ratio) play a crucial role in football performance (Almagiá Flores et al., 2008).

Previous studies have identified strong relationships between appropriate body composition (e.g., a higher fat-free mass, an optimal fat percentage, and a balanced muscle-to-fat ratio), vertical jump height and repeated sprinting ability performance (Nobari et al., 2021; Rebelo et al., 2013).

Beyond leaner body compositions, lower-body strength measurements are strongly correlated with acceleration, sprinting, changes of direction, and jumping performance in football players (Comfort et al., 2014; Oliveira et al., 2021).

In this context, the relationship between running performance and body composition has been evaluated in elite males, with findings indicating that players with a better muscle-to-fat ratio tend to perform more high-intensity actions and cover longer distances during matches.

Regarding female football players, Randell et al., (2021) conducted a review of anthropometric data collected between 2000 and 2020 from elite adult female football players. These players had an average age between 19-26 years, an average height between 161-170 cm, a body weight between 56.6-65.1 kg, and a fat percentage between 14.5-22.0%.

Thus, considering the previous aspects, it might be important to include them in the female football player performance puzzle.

Despite research on body composition and its impact on football performance has increased significantly (Bernal-Orozco et al., 2020; Hernandez-Martinez et al., 2024), studies focusing on highly trained female football players are scarce.

Furthermore, those examining the relationship between body composition and performance in key football actions also remains limited.

Consequently, the present study aimed to analyze the influence of body composition variables-body fat, skeletal muscle mass, and fat-free mass-on performance measures related to jumping ability, speed, and change of direction (COD) in highly trained adult female football players.

RBNE
Revista Brasileira de Nutrição Esportiva

In addition, it sought to identify differences in performance among players based on their body composition levels.

MATERIALS AND METHODS

Experimental Approach to the Problem

This study followed a cross-sectional design conducted during the competitive phase of the season (i.e., the seventh month). The study aimed to analyze the relationship between body composition and physical performance variables, such as vertical jump height and repeated sprinting ability, in highly trained female football players.

All assessments were performed under standardized conditions to ensure consistency. Players were instructed to maintain their regular training schedules to minimize external influences on performance.

All anthropometric evaluations were conducted in the early morning hours, between 08:00 and 10:00 a.m., under consistent environmental and room conditions (temperature: 22-24 ºC, humidity: 55–65%), while performance tests were carried out on an artificial turf football field during the early days of the week, between 5:00 and 7:00 p.m. (temperature: 20-25°C, humidity: 45-55%).

Each assessment followed a strict protocol regarding location, testing sequence, and equipment calibration to ensure accuracy and reliability.

Subjects

Thirty-eight highly trained female football players (age: 23.7 ± 3.86 years; height: 164 ± 5.45 cm; weight: 60.1 ± 5.55 kg) from two teams competing in the same division (Spanish Women's Second Division) volunteered to take part in the present study. Inclusion criteria were as follows: they were required to have at least six years of experience in football training and competition and regular participation in training sessions and matches for a minimum of six months before data collection.

In addition, only players who were injury-free at the time of the study and adhered strictly to the prescribed dietary guidelines without following any other specific diet plans were considered suitable for inclusion.

All players were fully informed about the study's purpose and procedures and voluntarily agreed to participate. They were confirmed free from injuries or health conditions that could influence the study's outcomes. The players trained for 7.5 hours per week, consisting of four sessions of 1.5 hours each, along with one competitive match.

Moreover, all participants obtained medical clearance from their respective clubs to participate in the study and were instructed to avoid any medication intake throughout the study period. Written informed consent was obtained from each player before the commencement of the study.

This research used the ethical principles outlined in the Declaration of Helsinki and received approval from the Local Ethics Committee of Clinical Research (PI21/011, CEICA, Spain).

Body Composition

Body composition assessments were conducted before training sessions, with participants in a fasted state and following urination.

During the measurements, the players wore appropriate clothing (shorts and t-shirt) to ensure accuracy.

Following the ISAK international standards, two ISAK Level 3 certified anthropometrists performed the assessments (Esparza-Ros et al., 2019).

Measurement instruments were carefully calibrated before each use, and all data were collected in duplicate to ensure reliability (Burgos et al., 2009).

Participants completed a 24-hour food recall before the pre- and post-testing sessions to minimize potential dietary influences on body composition assessments. A registered dietitian collected this information using the DAPA Measurement Toolkit (Cambridge, UK) to monitor average macronutrients and energy intake.

The obtained data were subsequently analyzed using the Spanish Food Composition Database (BEDCA), which compiles nutritional information from multiple sources and food composition tables (Burgos et al., 2009).

Body mass was assessed for each participant using a Tanita BC-601 scale (Tanita Corporation, Tokyo, Japan), while height was measured with a Seca 214 stadiometer (SECA GMBH & Co., Hamburg, Germany).

Skinfold thickness was measured at eight standard ISAK anatomical sites-triceps, biceps, abdominal, iliac crest, supraspinal,

RBNE
Revista Brasileira de Nutrição Esportiva

subscapular, front thigh, and medial calf-using a Harpenden skinfold caliper (Harpenden, West Sussex, UK).

Furthermore, four girth measurements were taken at the arm (relaxed and tensed), mid-thigh and calf using a Rosscraft steel tape (Rosscraft Innovations, Vancouver, Canada).

Bone breadth measurements were carried out at three sites-biepicondylar humerus, biepicondylar femur, and bi-styloid wrist diameter-using a Rosscraft Campbell caliper (Rosscraft Innovations, Vancouver, Canada).

Each anthropometric measurement was performed twice to ensure accuracy, and the interobserver and intraobserver technical measurement error was less than 1.5% for all variables except for skinfolds, which was less than 5.5%.

Body mass index (BMI) was determined by dividing body mass by height squared (kg/m^2) (Keys et al., 1972).

The sum of six skinfolds (Σ6S), including triceps, subscapular, supraspinal, abdominal, front thigh, and medial calf, was used to estimate body composition parameters (Canda, 2012).

Body density was calculated following the equation proposed for female athletes (Withers et al., 1987). Once body density was obtained, fat mass was estimated using the Siri equation (Siri, 1956), which differentiates between fat and fat-free mass. Skeletal muscle mass was determined using the equation developed by Lee et al., (2000).

The fat mass, fat-free body mass, and skeletal muscle mass were expressed in kilograms and as percentages.

Physical performance tests

Physical performance assessments included bilateral and unilateral countermovement jump (CMJ) tests, bilateral and unilateral horizontal jump tests, 40-m linear sprints, and the 505 COD test. Prior to data collection, all participants completed a standardised warm-up protocol based on the Raise, Activate, Mobilise, and Potentiate (RAMP) method (Jeffreys, 2006).

Each test was performed twice, with the best result recorded for further analysis. A rest period of three minutes was provided between each trial to ensure adequate recovery. Sprint and COD performance were measured using a photoelectric cell timing system (Witty, Microgate, Bolzano, Italy), while CMJ performance was assessed with a dual photocell system that calculates jump height based on flight time (OptoJump, Microgate, Mahopac, New York, USA). The intra-class correlation coefficient (ICC) for all tests ranged from 0.84 to 0.93, and the coefficient of variation (CV) was less than 10%.

Bilateral and Unilateral Countermovement Jump

The CMJ was used to assess lower-limb explosive power. Participants performed the test in both bilateral and unilateral conditions, with separate recordings for right and left legs.

They started in an upright position with their hands placed on their hips to eliminate arm swing contribution. The movement involved an eccentric phase with knee and hip flexion, followed by an explosive concentric action aiming to reach the highest possible jump height.

The reliability of these measurements was confirmed by an Intraclass Correlation Coefficient (ICC) of 0.89 to 0.99 and a coefficient of variation (CV) of less than 5%.

Bilateral and Unilateral Horizontal Jump

The horizontal jump test was conducted to assess lower-body power in the horizontal plane, using both bilateral and unilateral conditions, with separate measurements for right and left legs. In the bilateral horizontal jump, participants started from a standing position, feet placed behind a marked line, and performed a maximal effort jump forward after a preparatory countermovement involving knee and hip flexion.

The jump distance was measured from the take-off line to the nearest point of contact upon landing. In the unilateral horizontal jump, the same procedure was followed, but participants performed the jump using only one leg, alternating between right and left. Only jumps in which participants-maintained balance upon landing were considered valid. The ICC achieved ranged from 0.92 to 0.98 for these tests and a CV of less than 5%.

40m Linear Sprint

The 40m sprint test was used to evaluate linear speed, incorporating split times every 10m to analyse acceleration phases. Participants adopted a standing start position, with their preferred foot placed behind the starting line.

Upon the starting signal, they sprinted maximally over a 40m distance, with intermediate times recorded at 10, 20, and 30m, in addition to the total sprint time at 40m. Moreover, peak speed was computed using the formula: [(10/time 30-40m) x 3600] / 1000. The reliability of this measurement was confirmed by an ICC ranging from 0.86 to 0.96 and a CV of less than 5%.

505 Change of Direction Test

The 505 COD test was conducted to assess acceleration, braking, and rapid change of direction ability. Participants performed a 15m sprint, crossed the 5m mark, executed a 180° turn, and returned to the starting position. Timing was recorded from the 10m mark, focusing on the important COD phase. Each participant completed the test in both right and left turning directions. The percentage-based COD deficit was calculated using the formula: ([COD time – 10m sprint time] / 10m sprint time) x 100 (Bishop et al., 2021). The reliability of this test was confirmed by an ICC of 0.80 to 0.87 and a CV of less than 5%.

Statistical analysis

All statistical analyses were performed using SPSS (version 25) and Microsoft Excel. Data are presented as mean (SD). Reliability was assessed by ICC and CV using a spreadsheet. Normality was assessed using the Shapiro-Wilk test, which confirmed normal distribution for all variables, with the exception of interlimb asymmetries.

Pearson correlation was used to assess the relationships between percentage and absolute values (kg) of body fat (Whiters and Lee) and fat-free mass with the other variables.

The magnitude of the correlation (r [95% CI]) was interpreted according to Hopkins et al., (2009) using the following thresholds: ≤0.1 = trivial; >0.1–0.3 = small; >0.3–0.5 = moderate; >0.5–0.7 = large; >0.7–0.9 = very large; and >0.9–1.0 = almost perfect. Cohen's d effect sizevalues were classified as follows: trivial (<0.2), small (>0.2), moderate (>0.5), and large (>0.8).

The median split technique divided players into high or low %body fat or fat free mass and compared them using independent t tests.

Differences in asymmetries were analyzed with Friedman analysis of variance (p<.05).

RESULTS

Table 1 shows the relationships between absolute values (kg) and percentages of body fat, body skeletal muscle mass, and fat-free mass with the performance variables. No significant relationships (p>0.05) were found between those related to body fat, body skeletal muscle mass, and fat-free mass with COD performance and deficit variables. Significant relationships (r= -0.47 to 0.46; p<0.05) were reported between 30-m, 40-m, and peak velocity with body fat percentage (Whiters) and body skeletal muscle mass percentage and kg (Lee), and fat-free mass percentage.

Table 1 - Correlation Analysis Between Body Composition and Physical Performance Variables.

	CMJR	CMJL	CMJ	CMJ Asy	HJR	HJL	HJ	HJ Asy	10-m	20-m	30-m	40-m	Peak Vel	CODR	CODL	COD Asy	CODDR	CODDL	CODD Asy
Body fat Whiters (kg)	-0.24	-0.24	-0.14	-0.06	-0.32*	-0.27	-0.18	0.09	0.24	0.26	0.28	0.31	-0.31	0.14	0.19	-0.05	-0.11	-0.08	0.00
Body fat %Whiters (%)	-0.28	-0.26	-0.16	-0.04	-0.31	-0.28	-0.31	0.06	0.19	0.29	0.34*	0.39*	-0.39*	0.16	0.24	0.06 (	-0.04	-0.00	0.05
Body skeletal muscle mass Lee (kg)	0.33*	0.22	0.09	0.10	0.09	0.13	0.27	0.04	-0.22	-0.36	-0.41*	-0.47*	0.46*	-0.05	-0.08	-0.23	0.12	0.11	-0.12
Body skeletal muscle mass Lee (%)	0.36*	0.31	0.19	0.14	0.26	0.20	0.01	-0.02	-0.40*	-0.35*	-0.35*	-0.38*	0.37*	-0.04	-0.11	0.05	0.29	0.26	0.06
Fat Free Mass (kg)	0.12	0.05	0.00	-0.01	-0.02	0.04	0.36*	0.04	0.08	-0.14	-0.22	-0.27	0.27	-0.09	-0.09	-0.30	-0.14	-0.14	-0.19
Fat Free Mass (%)	0.29	0.26	0.16	0.04	0.31	0.28	0.31	-0.06	-0.19	-0.29	-0.34*	-0.39*	0.39*	-0.16	-0.24	-0.06	0.04	0.00	-0.05

COD, change of direction; CMJR and CMJL, countermovement jump with right and left; CMJ Asy, CMJ asymmetry; HJR and HJL, horizontal jump with right and left; HJ, horizontal jump; Peak Vel, peak velocity; HJ Asy, horizontal jump asymmetry; CODR and CODL indicate 180° COD right and left; COD Asy, change of direction asymmetry; CODDR and CODDL, COD deficit with right and left; CODD Asy, COD deficit asymmetry

Table 2 shows the differences between those female players who were considered low or high body fat percentage by Whiters. Significant lower values ($p<0.05$; ES: -2.87 to -0.77) were found in body mass index and relative and absolute body fat in the low group. Furthermore, greater significant performance ($p<0.05$; ES: -0.78 to 0.68) was found in the low group in HJR, HJL, 20-m, 30-m, 40-m, and peak velocity compared to the high body fat group.

Table 3 shows the differences between those female players who were considered to have low or high body skeletal muscle mass percentages by Lee. Significant lower values ($p<0.01$; ES: -2.34 to -0.79) were found in relative and absolute body skeletal muscle mass in the low group, while significantly greater values ($p<0.05$; ES: 0.67 to 0.69) were found in body mass and body mass index. Furthermore, greater significant performance ($p<0.05$; ES: 0.56) was found in the high group in 10-m, while a significantly lower CODDR ($p<0.05$; ES: -0.58) was reported in the low group compared to the high group.

Table 4 shows the differences between female players who are considered to have low or high fat-free mass. Significant greater fat free mass (%) ($p<0.01$; ES: 2.87) was found in the high group. Furthermore, greater significant performance ($p<0.05$; ES: -0.78 to 0.68) was found in the high group in HJR, HJL, 20-m, 30-m, 40-m, and peak velocity compared to the low group.

Table 2 - Analysis of All Variables Between High- and Low Whiters Groups.

Variable	Low Whiters% (n=19)	High Whiters% (n=19)	p-value	ES (CI95%)
Age (y)	23.9 ± 4.02	23.6 ± 3.79	0.41	0.07 (-0.56; 0.71)
Height (cm)	165.3 ± 5.52	162.6 ± 5.18	0.06	0.50 (-0.14; 1.14)
Body mass (kg)	58.9 ± 4.77	61.4 ± 6.12	0.09	-0.44 (-1.08; 0.21)
BMI	21.6 ± 1.77	23.2 ± 2.47	0.01*	-0.77 (-1.42; -0.10)
Body fat Whiters (kg)	8.00 ± 1.14	11.6 ± 1.92	<0.001*	-2.26 (-3.08; -1.43)
Body fat Whiters (%)	13.6 ± 1.75	18.8 ± 1.89	<0.001*	-2.87 (-3.77; -1.94)
CMJR (cm)	13.9 ± 1.60	13.2 ± 1.97	0.12	0.38 (-0.26; 1.02)
CMJL (cm)	13.8 ± 1.38	13.2 ± 1.71	0.11	0.39 (-0.24; 1.04)
CMJ (cm)	28.0 ± 2.12	27.5 ± 2.34	0.24	0.23 (-0.41; 0.87)
CMJ Asy (%)	5.41 ± 5.00	5.35 ± 5.40	0.49	0.01 (-0.62; 0.65)
HJR (cm)	150.2 ± 9.56	142.6 ± 13.5	0.03*	0.64 (-0.01; 1.29)
HJL (cm)	150.8 ± 10.2	143.2 ± 11.3	0.02*	0.68 (0.02; 1.33)
HJ (cm)	176.3 ± 11.3	171.2 ± 11.0	0.08	0.45 (-0.19; 1.09)
HJ Asy (%)	2.53 ± 1.65	2.23 ± 1.92	0.30	0.17 (-0.47; 0.80)
10-m (s)	1.90 ± 0.13	1.95 ± 0.24	0.24	-0.23 (-0.87; 0.41)
20-m (s)	3.29 ± 0.22	3.41 ± 0.18	0.04*	-0.60 (-1.24; 0.05)
30-m (s)	4.62 ± 0.32	4.80 ± 0.24	0.02*	-0.65 (-1.30; 0.00)
40-m (s)	5.98 ± 0.39	6.26 ± 0.29	0.01*	-0.78 (-1.43; -0.11)
Peak velocity (km/h)	27.5 ± 2.08	26.4 ± 1.87	0.04*	0.59 (-0.06; 1.24)
CODR (s)	2.59 ± 0.15	2.67 ± 0.20	0.07	-0.48 (-1.11; 0.17)
CODL (s)	2.57 ± 0.11	2.66 ± 0.22	0.05	-0.54 (-1.18; 0.11)
COD Asy (%)	3.22 ± 3.27	3.42 ± 2.28	0.41	-0.07 (-0.71; 0.56)
CODDR (%)	36.4 ± 9.84	39.9 ± 25.3	0.29	-0.18 (-0.81; 0.46)
CODDL (%)	35.2 ± 9.02	39.0 ± 23.8	0.25	-0.22 (-0.85; 0.42)
CODD Asy (%)	11.3 ± 9.95	10.9 ± 9.80	0.45	0.04 (-0.59; 0.67)

BMI, body mass index; COD, change of direction; CMJR and CMJL, countermovement jump with right and left; CMJ Asy, CMJ asymmetry; HJR and HJL, horizontal jump with right and left; HJ, horizontal jump; HJ Asy, horizontal jump asymmetry; CODR and CODL indicate 180° COD right and left; COD Asy, change of direction asymmetry; CODDR and CODDL, COD deficit with right and left; CODD Asy, COD deficit asymmetry; ES, effect size; CI, confidence interval

RBNE
Revista Brasileira de Nutrição Esportiva

Table 3 - Analysis of All Variables Between High- and Low-Lee% Groups.

Variable	Low Lee% (n=20)	High Lee% (n=18)	p-value	ES (CI95%)
Age (y)	23.7 ± 3.33	23.8 ± 4.47	0.46	-0.03 (-0.67; 0.60)
Height (cm)	163.8 ± 5.70	164.2 ± 5.33	0.42	-0.06 (-0.69; 0.57)
Body mass (kg)	61.9 ± 5.46	58.2 ± 5.13	0.02*	0.69 (0.03; 1.33)
BMI	23.1 ± 2.31	21.6 ± 2.04	0.02*	0.67 (0.01; 1.32)
Body skeletal muscle mass Lee (kg)	22.6 ± 2.12	24.2 ± 1.88	0.01*	-0.79 (-1.45; -0.13)
Body skeletal muscle mass Lee (%)	36.6 ± 2.23	41.6 ± 1.97	<0.001*	-2.34 (-3.22; -1.54)
CMJR (cm)	13.3 ± 2.01	13.8 ± 1.55	0.21	-0.26 (-0.90; 0.38)
CMJL (cm)	13.3 ± 1.60	13.8 ± 1.55	0.16	-0.33 (-0.97; 0.32)
CMJ (cm)	27.8 ± 2.29	27.6 ± 2.19	0.40	0.08 (-0.56; 0.72)
CMJ Asy (%)	4.80 ± 4.60	6.02 ± 5.73	0.24	-0.23 (-0.87; 0.41)
HJR (cm)	146.4 ± 12.8	146.4 ± 11.8	0.50	0.00 (-0.64; 0.64)
HJL (cm)	148.0 ± 12.2	146.2 ± 10.4	0.32	0.15 (-0.48; 0.79)
HJ (cm)	175.0 ± 9.61	172.2 ± 13.1	0.22	0.25 (-0.39; 0.88)
HJ Asy (%)	2.27 ± 1.77	2.52 ± 1.82	0.33	-0.14 (-0.78; 0.49)
10-m (s)	1.98 ± 0.17	1.87 ± 0.21	0.04*	0.56 (-0.09; 1.21)
20-m (s)	3.39 ± 0.23	3.31 ± 0.18	0.13	0.37 (-0.27; 1.01)
30-m (s)	4.76 ± 0.31	4.66 ± 0.28	0.15	0.34 (-0.30; 0.98)
40-m (s)	6.18 ± 0.37	6.06 ± 0.36	0.17	0.31 (-0.33; 0.95)
Peak velocity (km/h)	26.6 ± 1.82	27.4 ± 2.23	0.16	-0.39 (-1.03; 0.25)
CODR (s)	2.61 ± 0.17	2.65 ± 0.19	0.26	-0.21 (-0.85; 0.43)
CODL (s)	2.61 ± 0.17	2.62 ± 0.19	0.43	-0.05 (-0.69; 0.58)
COD Asy (%)	3.03 ± 2.25	3.64 ± 3.31	0.25	-0.22 (-0.85; 0.42)
CODDR (%)	33.1 ± 13.8	43.8 ± 22.6	0.04*	-0.58 (-1.22; 0.08)
CODDL (%)	32.9 ± 14.5	41.2 ± 20.4	0.06	-0.50 (-1.15; 0.15)
CODD Asy (%)	10.2 ± 9.33	12.1 ± 10.3	0.28	-0.19 (-0.83; 0.44)

BMI, body mass index; COD, change of direction; CMJR and CMJL, countermovement jump with right and left; CMJ Asy, CMJ asymmetry; HJR and HJL, horizontal jump with right and left; HJ, horizontal jump; HJ Asy, horizontal jump asymmetry; CODR and CODL indicate 180° COD right and left; COD Asy, change of direction asymmetry; CODDR and CODDL, COD deficit with right and left; CODD Asy, COD deficit asymmetry; ES, effect size; CI, confidence interval

Table 4 - Analysis of All Variables Between High- and Low-FFM% Groups.

Variable	High FFM% (n=19)	Low FFM% (n=19)	p-value	ES (CI95%)
Age (y)	23.8 ± 4.02	23.6 ± 3.79	0.41	0.07 (-0.56; 0.71)
Height (cm)	165.3 ± 5.52	162.6 ± 5.18	0.06	0.50 (-0.14; 1.14)
Body mass (kg)	58.9 ± 4.77	61.4 ± 6.12	0.09	-0.44 (-1.08; 0.21)
BMI	21.6 ± 1.77	23.2 ± 2.47	0.01*	-0.77 (-1.42; .0.10)
FFM (kg)	50.9 ± 4.35	49.8 ± 4.74	0.22	0.25 (-0.39; 0.89)
FFM (%)	86.4 ± 1.74	81.2 ± 1.89	<0.001*	2.87 (1.94; 3.78)
CMJR (cm)	13.9 ± 1.60	13.2 ± 1.96	0.12	0.38 (-0.26; 1.02)
CMJL (cm)	13.8 ± 1.38	13.2 ± 1.71	0.11	0.39 (-0.25; 1.04)
CMJ (cm)	28.0 ± 2.12	27.5 ± 2.35	0.24	0.23 (-0.41; 0.87)
CMJ Asy (%)	5.40 ± 5.00	5.35 ± 5.40	0.49	0.01 (-0.62; 0.65)
HJR (cm)	150.2 ± 9.56	142.6 ± 13.5	0.03*	0.64 (-0.01; 1.29)
HJL (cm)	150.8 ± 10.2	143.5 ± 11.3	0.02*	0.68 (0.02; 1.33)
HJ (cm)	176.3 ± 11.3	171.2 ± 11.0	0.08	0.45 (-0.19; 1.09)
HJ Asy (%)	2.54 ± 1.65	2.24 ± 1.92	0.30	0.17 (-0.47; 0.80)
10-m (s)	1.90 ± 0.13	1.95 ± 0.24	0.24	-0.23 (-0.87; 0.41)
20-m (s)	3.29 ± 0.22	3.42 ± 0.18	0.04*	-0.60 (-1.24; 0.05)
30-m (s)	4.62 ± 0.32	4.80 ± 0.24	0.02*	-0.65 (-1.30; 0.00)
40-m (s)	5.98 ± 0.39	6.26 ± 0.29	0.01*	-0.78 (-1.43; -0.11)
Peak velocity (km/h)	27.5 ± 2.08	26.4 ± 1.87	0.04+	0.59 (-0.06; 1.24)
CODR (s)	2.59 ± 0.15	2.67 ± 0.20	0.07	-0.47 (-1.12; 0.17)
CODL (s)	2.57 ± 0.11	2.66 ± 0.22	0.05	-0.54 (-1.18; 0.11)
COD Asy (%)	3.21 ± 3.27	3.42 ± 2.28	0.41	-0.07 (-0.71; 0.56)
CODDR (%)	36.4 ± 9.84	39.9 ± 25.3	0.29	-0.18 (-0.82; 0.46)
CODDL (%)	35.2 ± 9.02	39.0 ± 23.8	0.25	-0.22 (-0.85; 0.42)
CODD Asy (%)	11.3 ± 9.95	10.9 ± 9.80	0.45	0.04 (-0.60; 0.67)

BMI, body mass index; COD, change of direction; CMJR and CMJL, countermovement jump with right and left; CMJ Asy, CMJ asymmetry; HJR and HJL, horizontal jump with right and left; HJ, horizontal jump; HJ Asy, horizontal jump asymmetry; CODR and CODL indicate 180° COD right and left; COD Asy, change of direction asymmetry; CODDR and CODDL, COD deficit with right and left; CODD Asy, COD deficit asymmetry; ES, effect size; CI, confidence interval

DISCUSSION

The present study aimed to analyze the influence of body composition variables-body fat, skeletal muscle mass, and fat-free mass-on performance measures related to jumping ability, speed, and COD in highly trained adult female football players. In addition, it sought to identify differences in performance among players based on their body composition levels.

The main findings of the study were: (1) significant correlations between several performance variables, including 30-m, 40-m, and peak velocity with body fat percentages (Whiters), body skeletal muscle mass (Lee), and fat-free mass percentage (r = -0.47 to 0.46, p<0.05), highlighting the relationship between body composition and sprinting performance; (2) no significant correlations (p>0.05) were found between body fat, body skeletal muscle mass, and fat-free mass with COD performance and deficit variables; (3) players classified with lower body fat percentage (Whiters) showed significantly better performance in HJR, HJL, 20-m, 30-m, 40-m, and peak velocity compared to those with higher body fat (p<0.05, ES: -0.78 to 0.68), indicating a positive influence of lower fat levels on physical performance; (4) comparative analysis based on Lee's body skeletal muscle mass classification revealed significant differences in body mass and BMI, with better 10-m sprint performance in the high-muscle mass group (p<0.05, ES: 0.56), while a significantly lower CODD (p<0.05, ES: -0.58) was found in the low- muscle mass group; and (5) players with higher fat-free mass percentage exhibited superior performance in HJR, HJL, 20-m, 30-m, 40-m, and peak velocity (p<0.05, ES: -0.78 to 0.68), emphasizing the role of this in athletic performance.

Some previous studies have reviewed the relationship between body composition and performance in football, highlighting the significant correlations that could exist between

(França et al., 2024; Silvestre et al., 2006; Stanković et al., 2023).

The results obtained in the present study showed significant correlations between sprint speed (30-m, 40-m, and peak velocity) and body composition parameters, such as body fat percentage, skeletal muscle mass (absolute and relative), and fat-free mass percentage ($p<0.05$).

These results align with other authors who found similar correlations (França et al., 2024; Silvestre et al., 2006).

However, different results were obtained by Stanković et al., (2023) with elite female football players, who found no significant correlation between 20-meter sprinting with body fat (kg: $p>0.05$, $r = 0.25$; %: $p>0.05$, $r = 0.33$), and muscle mass (kg: $p>0.05$, $r = -0.11$; %: $p=0.05$, $r = -0.44$).

The differences observed between studies could be attributed to methodological differences in body composition assessment, such as the use of skinfold thickness measurements, bioelectrical impedance analysis, and dual-energy X-ray absorptiometry (DXA), as well as and the specific sprint distances (30-m and 40-m vs. 20-m) analyzed.

Therefore, sprint performance in highly trained female football players might improve with more optimal body composition values (lower body fat percentage and higher muscle mass). It highlights the importance of appropriate nutrition and strength training programs to optimize body composition and, ultimately, enhance sprint performance, a key factor for success in football.

Performing quick CODs is crucial for football performance (Aziz et al., 2000; Little, Williams, 2007). However, higher linear velocity values do not necessarily translate into better COD performance (Roso-Moliner et al., 2023).

This study found no significant correlations between body composition and COD performance ($p>0.05$, r: -0.24 to 0.24) or CODD values ($p>0.05$, r: -0.14 to 0.29), consistent with Stanković et al., (2023) who reported no significant correlations between body fat (kg: $p>0.05$, $r = 0.34$; %: $p>0.05$, $r = 0.42$), fat-free mass (kg: $p>0.05$, $r = 0.02$; %: $p>0.05$, $r = -0.29$) or muscle mass (kg: $p>0.05$, $r = -0.07$) and the 505 test, except for a significant correlation between muscle mass percentage ($p<0.05$, $r = -0.47$).

Another study (França et al., 2024) found significant correlations between % body fat ($p<0.01$, $r = 0.33$) and fat-free mass ($p < 0.01$, $r = -0.32$) with the t-test, but not with body mass ($p>0.05$, $r = -0.16$) in youth male football players. However, conflicting findings suggest further research is needed, considering factors like pre-COD distance, total distance, COD angle, and frequency.

As in many team sports, in football, unilateral force application in the horizontal plane is determinant. Studies show strong correlations between unilateral horizontal jumping, acceleration, and sprinting (Kugler, Janshen, 2010; Lin et al., 2023; Maulder, Cronin, 2005) his study found that players with lower body fat performed significantly better in HJR and HJL ($p<0.05$, ES: 0.64-0.68), and 20-m, 30-m, 40-m sprints, and peak velocity ($p<0.05$, ES: -0.78–0.59) than those with higher body fat.

Similarly, Ostojic et al., (2003), found a strong correlation ($p<0.05$) between 50-m sprint times and body fat on elite football players, with performance improving as fat decreased, and Toselli et al., (2022) reported better 15-m sprint times in U-15 and U-12 players with lower body fat. However, some studies suggest sprint performance varies by position, indicating positional demands may influence this relationship (Hernandez-Martinez et al., 2024; Kammoun et al., 2020). It indicates that the specificity of the playing position may play a decisive role in sprint performance.

The classification based on skeletal muscle mass revealed significant differences in body mass (kg) and BMI, suggesting a strong relationship with players' morphology.

However, findings in the literature remain inconsistent. Bernal-Orozco et al., 2020) reported similar results in some cases but not in others, highlighting variability across different ages and categories in football. Our results indicate that players with higher muscle mass performed better in the 10-m sprint ($p<0.05$, ES: 0.56), while those with lower muscle mass had a reduced CODDR ($p<0.05$, ES: -0.58) and a moderate, but non-significant, effect in CODDL ($p=0.06$, ES = -0.50).

These findings align with research in male football players showing a moderate correlation between muscle mass and 30-m sprint ($p<0.05$, $r = -0.36$) (Anwar, Noohu, 2016), but contrast with studies reporting no relationship in a 9.1-m sprint test (Silvestre et al., 2006).

Given that sprint performance may be distance-dependent, further research is needed to clarify these associations. To our knowledge,

RBNE
Revista Brasileira de Nutrição Esportiva

no study has directly analyzed the relationship between skeletal muscle mass and CODD.

Previous research linked CODD to performance and lower limb asymmetries but not to body composition (Bishop et al., 2021; Freitas et al., 2021; Freitas et al., 2022). One study (Roso-Moliner et al., 2024) explored CODD and body mass, reporting no significant correlation (p>0.05, r: -0.08 to 0.16).

These findings highlight the need for further research to determine the role of skeletal muscle mass in CODD ability and its potential impact across different sprint distances.

Several studies have examined the relationship between fat-free mass and sports performance (Miller et al., 2002; Sawyer et al., 2002; Stuempfle et al., 2003) with higher muscle mass values commonly associated with greater strength and power levels (Aguilera et al., 2013). n this study, players with greater fat-free mass demonstrated superior performance in the unilateral horizontal jump (p<0.05, ES: 0.64 to 0.68), 20-m sprint (p<0.05, ES: -0.78 to -0.60), and peak velocity (p<0.05, ES = 0.59).

These findings align with those of Nikolaidis et al., (2016) who reported significant correlations between fat-free mass and sprint performance at 10-m (p<0.01, r = 0.21) and 20-m (p<0.05, r = 0.16), as well as other studies showing associations between fat-free mass and sprint times at 10-m (p<0.05, r = -0.24) and 35-m (p<0.01, r = 0.65) in youth football players (França et al., 2024).

However, the relationship between fat-free mass and lower-body power remains inconsistent depending on the type of jump assessment. In this study, horizontal jump performance was significantly correlated with fat-free mass, whereas vertical jump performance was not (p>0.05, ES: 0.01 to 0.39).

These results are consistent with those of Silvestre et al., (2006) who found no significant association between fat-free mass and vertical jump performance in collegiate male football players.

Given that forward propulsion requires maximal horizontal force application (Kugler, Janshen, 2010), it is plausible that fat-free mass contributes more significantly to horizontal jump performance than to vertical jumps

Some limitations should be considered: the sample was not classified by playing positions, common in women's football research, making comparisons with other studies challenging. However, the classification method used here provides a more direct relationship between body composition and performance variables.

Another limitation is the lack of research on body composition and CODD in female players.

Future studies should explore the relationships between diverse body composition parameters (e.g., body fat, skeletal muscle mass, fat-free mass) and performance.

Furthermore, future studies should incorporate more advanced and precise methods for assessing body composition, such as DXA, to improve the accuracy of measurements and facilitate comparisons across studies.

Further research with standardized sample classification could better establish the link between body composition and performance in women's football.

CONCLUSÃO

In summary, categorizing female football players based on body composition profiles rather than playing positions provides a more accurate assessment of its impact on performance, avoiding misclassification due to different morphotypes within the same position.

Teams should implement strategies to optimize players' body composition to enhance performance.

Coaches and physical trainers are encouraged to regularly assess body composition to detect deviations from optimal values and tailor training programs accordingly.

By individualizing training to focus on muscle gain or fat reduction as needed, teams can maximize both individual and collective performance.

DISCLOSURE STATEMENT

The authors report there are no competing interests to declare.

FUNDING

The authors reported no potential conflict of interest.

DATA AVAILABILITY STATEMENT

The manuscript's authors will make the data available upon request.

Orcid dos autores

Alberto Roso-Moliner 0000-0002-5359-1524
Oliver Gonzalo-Skok 0000-0002-7679-2062
Rafael Albalad-Aiguabella 0009-0005-0259-8725
Chris Bishop 0000-0002-1505-1287
Demetrio Lozano 0000-0001-5443-6721
Elena Mainer-Pardos 0000-0003-2947-9564

REFERENCES

1-Andersson, H.Å.; Randers, M.B.; Heiner-Møller, A.; Krustrup, P.; Mohr, M. Elite female soccer players perform more high-intensity running when playing in international games compared with domestic league games. Journal of Strength and Conditioning Research. Vol. 24. Num. 4. 2010. p. 912-919.

2-Almagiá Flores, A.A.; Rodríguez Rodríguez, F.; Barraza Gómez, F.O.; Lizana Arce, P.J.; Jorquera Aguilera, C.A. Perfil antropométrico de jugadoras chilenas de fútbol femenino. International Journal of Morphology. Vol. 26. Num. 4. 2008. p. 817-821.

3-Aziz, A.R.; Chia, M.Y.H.; Teh, K.C. The relationship between maximal oxygen uptake and repeated sprint performance indices in field hockey and soccer players. Journal of Sports Medicine and Physical Fitness. Vol. 40. Num. 3. 2000. p. 195-200.

4-Aguilera, C.; Rodríguez, F.; Ignacia, M.; Vieira, T.; Serrano, J.; Leiva, N. Anthropometric characteristics of Chilean professional football players. International Journal of Morphology. Vol. 31. Num. 2. 2013. p. 609-614.

5-Anwar, S.; Noohu, M.M. Correlation of percentage body fat and muscle mass with anaerobic and aerobic performance in collegiate soccer players. Indian Journal of Physiology and Pharmacology. Vol. 60. Num. 2. 2016. p. 137-144.

6-Bernal-Orozco, M.F.; Posada-Falomir, M.; Quiñónez-Gastélum, C.M.; Plascencia-Aguilera, L.P.; Arana-Nuño, J.R.; Badillo-Camacho, N.; et al. Anthropometric and body composition profile of young professional soccer players. Journal of Strength and Conditioning Research. Vol. 34. Num. 7. 2020. p. 1911-1923.

7-Bishop, C.; Clarke, R.; Freitas, T.T.; Arruda, A.F.; Guerriero, A.; Ramos, M.S. Change-of-direction deficit vs. deceleration deficit: a comparison of limb dominance and inter-limb asymmetry between forwards and backs in elite male rugby union players. Journal of Sports Sciences. Vol. 39. Num. 10. 2021. p. 1088-1095.

8-Bishop, C.; Brashill, C.; Abbott, W.; Read, P.; Lake, J.; Turner, A. Jumping asymmetries are associated with speed, change of direction speed, and jump performance in elite academy soccer players. Journal of Strength and Conditioning Research. Vol. 35. Num. 7. 2021. p. 1841-1847.

9-Burgos, M.M.; Martínez-Victoria, I.; Milá, R.; Farrán, A.; Farré, R.; Ros, G. Building a unified Spanish food database according to EuroFIR specifications. Food Chemistry. Vol. 113. Num. 3. 2009. p. 784-788.

10-Canda, A.S. Variables antropométricas de la población deportista española. Consejo Superior de Deportes, Servicio de Documentación y Publicaciones. 2012.

11-Comfort, P.; Stewart, A.; Bloom, L.; Clarkson, B. Relationships between strength, sprint, and jump performance in well-trained youth soccer players. Journal of Strength and Conditioning Research. Vol. 28. Num. 1. 2014. p. 173-177.

12-Esparza-Ros, F.; Vaquero-Cristóbal, R.; Marfell-Jones, M. International standards for anthropometric assessment. International Society for the Advancement of Kinanthropometry (ISAK). 2019.

13-FIFA. FIFA Big Count 2006: 270 million people active in football. FIFA Magazine. Zurique. Vol. 31. 2007. p. 1.

14-FIFA. Estratégia de Futebol Feminino. FIFA. Zurique. 2020. Disponível em: https://www.fifa.com/es/ womens-football/strategy/strategy-details

15-Freitas, T.T.; Pereira, L.A.; Alcaraz, P.E.; Azevedo, P.H.; Bishop, C.; Loturco, I. Percentage-based change of direction deficit: a new approach to standardize time- and velocity-derived calculations. Journal of Strength and

Conditioning Research. Vol. 36. Num. 12. 2022. p. 3521-3526.

16-Freitas, T.T.; Alcaraz, P.E.; Calleja-González, J.; Arruda, A.F.; Guerriero, A.; Kobal, R. Differences in change of direction speed and deficit between male and female national rugby sevens players. Journal of Strength and Conditioning Research. Vol. 35. Num. 11. 2021. p. 3170-3176.

17-Hernandez-Martinez, J.; Perez-Carcamo, J.; Canales-Canales, S.; Coñapi-Union, B.; Cid-Calfucura, I.; Herrera-Valenzuela, T. Body composition and physical performance by playing position in amateur female soccer players. Journal of Applied Sciences. Vol. 14. Num. 13. 2024. p. 5665.

18-França, C.; Gouveia, É.R.; Martins, F.; Ihle, A.; Henriques, R.; Marques, A. Lower-body power, body composition, speed, and agility performance among youth soccer players. Sports. Vol. 12. Num. 5. 2024. p. 135.

19-Hopkins, W.G.; Marshall, S.W.; Batterham, A.M.; Hanin, J. Progressive statistics for studies in sports medicine and exercise science. Medicine and Science in Sports and Exercise. Vol. 41. Num. 1. 2009. p. 3-13.

20-Kammoun, M.M.; Trabelsi, O.; Gharbi, A.; Masmoudi, L.; Ghorbel, S.; Tabka, Z. Anthropometric and physical fitness profiles of Tunisian female soccer players: associations with field position. Acta Gymnica. Vol. 50. Num. 3. 2020. p. 130-137.

21-Keys, A.; Fidanza, F.; Karvonen, M.J.; Kimura, N.; Taylor, H.L. Indices of relative weight and obesity. Journal of Chronic Diseases. Vol. 25. Num. 6-7. 1972. p. 329-343.

22-Krustrup, P.; Zebis, M.; Jensen, J.M.; Mohr, M. Game-induced fatigue patterns in elite female soccer. Journal of Strength and Conditioning Research. Vol. 24. Num. 2. 2010. p. 437-441.

23-Kugler, F.; Janshen, L. Body position determines propulsive forces in accelerated running. Journal of Biomechanics. Vol. 43. Num. 2. 2010. p. 343-348.

24-Jeffreys, I. Warm up revisited–the 'ramp' method of optimising performance preparation. Professional Strength and Conditioning. Vol. 6. 2006. p. 12-18.

25-Lago-Peñas, C.; Casais, L.; Dellal, A.; Rey, E.; Domínguez, E. Anthropometric and physiological characteristics of young soccer players according to their playing positions: relevance for competition success. Journal of Strength and Conditioning Research. Vol. 25. Num. 12. 2011. p. 3358-3367.

26-Lin, J.; Shen, J.; Zhang, J.; Zhou, A.; Guo, W. Correlations between horizontal jump and sprint acceleration and maximal speed performance: a systematic review and meta-analysis. PeerJ. Vol. 11. 2023. p. e14650.

27-Little, T.; Williams, A.G. Measures of exercise intensity during soccer training drills with professional soccer players. Journal of Strength and Conditioning Research. Vol. 21. Num. 2. 2007. p. 367-371.

28-Lee, R.C.; Wang, Z.; Heo, M.; Ross, R.; Janssen, I.; Heymsfield, S.B. Total-body skeletal muscle mass: development and cross-validation of anthropometric prediction models. The American Journal of Clinical Nutrition. Vol. 72. Num. 3. 2000. p. 796-803.

29-Maulder, P.; Cronin, J. Horizontal and vertical jump assessment: reliability, symmetry, discriminative and predictive ability. Physical Therapy in Sport. Vol. 6. Num. 2. 2005. p. 74-82.

30-Miller, T.A.; White, E.D.; Kinley, K.A.; Congleton, J.J.; Clark, M.J. The effects of training history, player position, and body composition on exercise performance in collegiate football players. Journal of Strength and Conditioning Research. Vol. 16. Num. 1. 2002. p. 44-49.

31-Mohr, M.; Krustrup, P.; Bangsbo, J. Match performance of high-standard soccer players with special reference to development of fatigue. Journal of Sports Sciences. Vol. 21. Num. 7. 2003. p. 519-528.

32-Nikolaidis, P.; Ruano, M.; Oliveira, N.; Portes, L.; Freiwald, J.; Lepretre, P.-M. Who runs the fastest? Anthropometric and physiological correlates of 20 m sprint performance in male soccer players. Research in Sports Medicine. Vol. 24. Num. 4. 2016. p. 341-351.

33-Nobari, H.; Kargarfard, M.; Minasian, V.; Cholewa, J.M.; Pérez-Gómez, J. The effects of 14-week betaine supplementation on endocrine markers, body composition and anthropometrics in professional youth soccer players: a double blind, randomized, placebo-controlled trial. Journal of the International Society of Sports Nutrition. Vol. 18. Num. 1. 2021. p. 20.

34-Oliveira, R.; Francisco, R.; Fernandes, R.; Martins, A.; Nobari, H.; Clemente, F.M. In-season body composition effects in professional women soccer players. International Journal of Environmental Research and Public Health. Vol. 18. Num. 22. 2021.

35-Ostojic, S. Seasonal alterations in body composition and sprint performance of elite soccer players. Journal of Exercise Physiology. Vol. 6. Num. 3. 2003. p. 11-14.

36-Randell, R.K.; Clifford, T.; Drust, B.; Moss, S.L.; Unnithan, V.B.; De Ste Croix, M.B.; Physiological characteristics of female soccer players and health and performance considerations: a narrative review. Sports Medicine. Vol. 51. 2021. p. 1377-1399.

37-Rebelo, A.; Brito, J.; Maia, J.; Coelho-e-Silva, M.; Figueiredo, A.; Bangsbo, J. Anthropometric characteristics, physical fitness and technical performance of under-19 soccer players by competitive level and field position. Journal of Sports Sciences. Vol. 34. Num. 4. 2013. p. 312-317.

38-Roso-Moliner, A.; Mainer-Pardos, E.; Cartón-Llorente, A.; Nobari, H.; Pettersen, S.A.; Lozano, D. Effects of a neuromuscular training program on physical performance and asymmetries in female soccer. Frontiers in Physiology. Vol. 14. 2023. p. 1171636.

39-Roso-Moliner, A.; Gonzalo-Skok, O.; Villavicencio Álvarez, V.E.; Calero-Morales, S.; Mainer-Pardos, E. Analysing the influence of speed and jumping performance metrics on the percentage change of direction deficit in adolescent female soccer players. Life. Vol. 14. Num. 4. 2024. p. 466.

40-Sawyer, D.T.; Ostarello, J.Z.; Suess, E.A.; Dempsey, M. Relationship between football playing ability and selected performance measures. Journal of Strength and Conditioning Research. Vol. 16. Num. 4. 2002. p. 611-616.

41-Siri, W. The gross composition of the body. Advances in Biological and Medical Physics. 1956.

42-Silvestre, R.; West, C.; Maresh, C.M.; Kraemer, W.J. Body composition and physical performance in men's soccer: a study of a national collegiate athletic association Division I team. Journal of Strength and Conditioning Research. Vol. 20. Num. 1. 2006. p. 177-183.

43-Stanković, M.; Čaprić, I.; Đorđević, D.; Đorđević, S.; Preljević, A.; Koničanin, A. Relationship between body composition and specific motor abilities according to position in elite female soccer players. International Journal of Environmental Research and Public Health. Vol. 20. Num. 2. 2023. p. 1327.

44-Stuempfle, K.J.; Katch, F.I.; Petrie, D.F. Body composition relates poorly to performance tests in NCAA Division III football players. Journal of Strength and Conditioning Research. Vol. 17. Num. 2. 2003. p. 238-244.

45-Toselli, S.; Mauro, M.; Grigoletto, A.; Cataldi, S.; Benedetti, L.; Nanni, G. Assessment of body composition and physical performance of young soccer players: differences according to the competitive level. Journal of Human Sport and Exercise. Vol. 11. Num. 6. 2022. p. 823.

46-Wehbe, G.M.; Hartwig, T.B.; Duncan, C.S. Movement analysis of Australian national league soccer players using global positioning system technology. Journal of Strength and Conditioning Research. Vol. 28. Num. 3. 2014. p. 834-842.

47-Withers, R.; Whittingham, N.; Norton, K.; La Forgia, J.; Ellis, M.; Crockett, A. Relative body fat and anthropometric prediction of body density of female athletes. European Journal of Applied Physiology and Occupational Physiology. Vol. 56. 1987. p. 169-180.

3 - Faculty of Science and Technology, London Sport Institute, Middlesex University, London NW4 4BT, UK.

Authors e-mail:
aroso@usj.es
oligons@hotmail.com
ralbalad@usj.es
c.bishop@mdx.ac.uk
dlozano@usj.es
epardos@usj.es

Corresponding author:
Health Sciences Faculty.
epardos@usj.es
Universidad San Jorge, Autov A23 km 299, 50830 Villanueva de Gállego, Zaragoza, Spain.

Recebido para publicação em 23/07/2025
Aceito em 24/08/2025