

Body composition and physical fitness as determinants of locomotor demands in professional women's football matches

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Abstract

Introduction: Women's football has experienced significant professional growth; however, integrated evidence linking body composition, physical fitness, and competitive external load remains limited, particularly when analysed by playing position. Understanding these relationships is essential to optimise performance and individualise training in professional female players within real match conditions. **Objective:** To compare body composition, physical fitness, and GPS-derived competitive external load according to playing position in professional women's football players, and to analyse the associations between morphofunctional characteristics and locomotor demands during competition. **Methods:** Twenty-three professional players competing in the Liga MX Femenil underwent assessments of body composition and physical fitness (strength, speed, power, and intermittent endurance), and were monitored using GPS during ten official matches. Positional differences were examined using one-way ANOVA, and associations between variables were analysed using Pearson's correlation coefficients. **Results:** Significant positional differences were observed in body mass, with goalkeepers presenting higher values than outfield players ($p < 0.05$). Forwards showed superior 30 m sprint performance and greater high-intensity external load, including high-speed running, sprint distance, maximal speed, and high metabolic load distance ($p < 0.05$). Higher fat mass and the sum of six skinfolds were negatively associated with neuromuscular performance and accelerations during competition, whereas sprint performance and intermittent endurance were positively associated with total distance and high metabolic load distance ($p < 0.05$). **Conclusions:** Body composition and physical fitness are key determinants of competitive locomotor demands in professional women's football, supporting the integration of morphofunctional assessments with GPS monitoring to guide position-specific training, prescription, and performance optimisation processes.

Keywords: positional demands; match performance; high-intensity actions; sprint capacity; training individualisation

Introduction

Women's football has experienced substantial growth over recent decades, both in terms of its professional structure and the volume of research related to physical and technical performance (Datson, 2016). Increased media visibility, professionalisation of the league, and greater investment in development programmes have enabled the sport to reach competitive standards increasingly comparable to those of men's football (Villaseca-Vicuña et al., 2021), albeit with physiological and contextual particularities that must be considered (FIFA, 2019). Within this context, the development of professional leagues has promoted a more scientific approach to player preparation, requiring precise information on aspects such as body composition, physical qualities, and match demands (Villaseca-Vicuña et al., 2023; 2024). This approach is essential not only for performance optimisation but also for reducing injury risk and extending players' athletic careers (Mujika et al., 2009; 2018). Despite this progress, the majority of sports science research has been conducted in men's football, with women's football remaining underrepresented (FIFA, 2019). In female football players, studies integrating body composition, physical fitness, and Global Positioning System (GPS) data are still limited and have largely been developed within regional contexts or specific competitive levels (Vescovi et al., 2011; 2021). Nevertheless, available evidence indicates that physical demands and performance characteristics vary according

to playing position in both men's and women's football, influencing total distance covered, sprint volume, maximal running speed, and the number of neuromuscular actions performed (Bradley et al., 2014; 2017). In Chilean first-division female players, body composition—particularly fat mass percentage and muscle mass percentage—has shown to be associated with performance in speed and power tests (Letelier-Acevedo et al., 2024). Similarly, correlations have been observed between countermovement jump (CMJ) performance and sprinting and change-of-direction ability, highlighting the importance of explosive strength across different on-field roles (Villaseca-Vicuña, 2021). However, findings regarding positional differences remain heterogeneous: while some studies report similar physical capacities across positions, others identify functional specificities that reflect the tactical demands of the role performed (Villaseca-Vicuña, 2021, 2024). The integration of internal variables (body composition and physical fitness) with external variables (competitive load measured via GPS) represents a key requirement for achieving a more comprehensive understanding of performance in professional female football players. However, this integrated approach remains insufficiently explored in women's football, particularly when analyses are differentiated by playing position (Villaseca-Vicuña, 2021), generating a knowledge gap that limits the practical application of scientific evidence (Bradley et al., 2014; 2017). Although the use of GPS technology has enabled substantial advances in the monitoring of external load, its connection with morphofunctional characteristics remains in its early stages (Merino-Muñoz et al., 2021; Villaseca-Vicuña et al., 2021; Zabaloy et al., 2022). Examining how body composition and physical fitness influence competitive performance may provide valuable information for coaches and technical staff, facilitating the development of functional profiles tailored to the specific demands of goalkeepers, defenders, midfielders, and forwards (Villaseca-Vicuña, Segueida-Lorca, et al., 2024). Such an approach would not only optimise preparation and recovery processes but also facilitate training individualisation and contribute to injury prevention strategies (Zabaloy et al., 2022). Therefore, the aim of this study was to compare body composition, physical fitness, and GPS-derived locomotor performance during competition in professional female football players according to the playing position, and to analyse the relationships between the variables assessed. It was hypothesised that players with a better body composition (greater muscle mass and lower fat mass percentage) and superior physical fitness (strength, speed, and intermittent endurance) would exhibit higher external load metrics (total distance covered, maximal speed, high speed running distance, sprint distance, and acceleration and deceleration actions), with expected differences according to playing position.

Methods

Design

The present study adopted a quantitative research design with descriptive, comparative, and correlational components. It was a retrospective study in which data obtained from routine assessments conducted throughout the competitive season were analysed. This approach enabled the integration of information from multiple sources (body composition, physical fitness, and competitive kinematic performance) and their cross-sectional examination, thereby enhancing the practical applicability of the findings.

Participants

The sample consisted of 23 female players from a professional team competing in the Liga MX Femenil, who participated in body composition and physical fitness assessments and were monitored using Global Positioning System (GPS) devices during official competitive matches. The selection of this sample was justified by its representativeness of a professional squad within an official competitive context. Regarding playing position distribution, the team comprised 3 goalkeepers (GK), 4 full-backs (FB), 4 centre-backs (CB), 6 midfielders (MF), and 6 forwards (FW), allowing for a comprehensive analysis that accounted for the specific demands associated with each tactical role. The variables analysed were organised into three main blocks: body composition, physical fitness, and external load.

Ethical Considerations

All procedures were conducted under standard football training conditions, without introducing additional motor tasks beyond those routinely performed during training sessions or competitive matches. All players were medically examined prior to the start of the season and completed the assessments free from injury or physical discomfort. The study was conducted in accordance with the principles of the Declaration of Helsinki (World Medical Association, 2013). The data presented in this study correspond to assessments carried out within the same club, with informed consent obtained from both the club and the players for data dissemination.

Procedures

Participants completed the assessments during the first two days of a weekly training microcycle. To minimise the influence of fatigue, all players were instructed to refrain from strenuous exercise for at least 24 hours prior to each testing session. Each testing day began with a standardised warm-up led by the strength and conditioning coach, consisting of light running, multidirectional movements, and dynamic stretching, followed by a test-specific warm-up according to the corresponding test battery (15–20 min). The assessment schedule was organised as follows: Day 1 included body composition evaluation, countermovement jump (CMJ), and strength assessments (dynamic and isometric); Day 2 comprised 10 m and 30 m sprint tests (T10 and T30, respectively) and the 30–15 Intermittent Fitness Test (30–15 IFT) to assess intermittent endurance capacity.

These tests are commonly applied in women's football teams (Letelier-Acevedo et al., 2024; Villaseca-Vicuña, Molina-Sotomayor, et al., 2021; Villaseca-Vicuña, Otero-Saborido, et al., 2021), as they provide valid information to characterise both body composition and physical fitness in female players. All participants were familiar with the testing procedures, as these form a regular part of their training programmes. During each test, players were verbally encouraged to perform at maximal effort in order to obtain reliable performance data. In addition, data from 10 official league matches played during the season were collected. Players wore GPS devices during each match to quantify indicators of physical performance in competition. On match days, all players completed a standardised warm-up lasting 20–25 min, which included general joint mobility exercises and football-specific tasks with the ball (passing drills, small-sided games, and offensive and defensive organisational tasks). To ensure data quality, only outfield players who completed more than 80 minutes of playing time and were free from injuries that could limit maximal effort during both competition and physical testing were included in the analysis.

Variables and Instruments

Body Composition

Body mass (BM) was measured using a calibrated digital scale (Seca®, Hamburg, Germany; accuracy 0.1 kg), and height (HT) was assessed with a portable stadiometer (Seca®, Hamburg, Germany; accuracy 0.1 cm). In addition, the sum of six skinfolds ($\Sigma 6SF$: triceps, subscapular, supraspinale, abdominal, medial thigh, and maximal calf) was recorded to estimate body fat percentage and muscle mass percentage (%FM and %MM). All procedures were conducted in accordance with the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK) and were performed by a Level II ISAK-certified anthropometrist. Skinfold thickness was measured using a Slim Guide calliper (Rosscraft®, British Columbia, Canada), with an accuracy of 0.2 mm.

Physical Fitness

Dynamic Strength (Back Squat Test)

This protocol has been validated for assessing lower-limb muscular strength in football players (González-Badillo & Sánchez-Medina, 2010). Prior to testing, each player completed a specific warm-up consisting of two sets of four repetitions with a light load of 20 kg, performing two repetitions at a controlled velocity and two at maximal voluntary velocity. Subsequently, four sets of back squats were performed to approximately 90° of knee flexion, using relative loads corresponding to ~50%, 60%, 70%, and 85% of the estimated one-repetition maximum (1RM), with three minutes of rest between sets. In all repetitions, the concentric phase was performed at maximal intended velocity, avoiding muscular failure in any set. The following variables were recorded: a) mean propulsive velocity at 50%, 60%, 70%, and 85% of 1RM (MPV50, MPV60, MPV70, and MPV85); b) relative strength (RS), calculated as the ratio between estimated 1RM and BM; c) estimated 1RM, determined from the mean propulsive velocity recorded at the final load using the equation proposed by González-Badillo and Sánchez-Medina (2010). All variables were obtained using a linear position transducer (Vitrue®, Madrid, Spain).

Isometric Strength (Isometric 90°:20° Hamstring Test and Isometric Belt Squat Test)

Isometric strength was assessed using two complementary protocols: the maximal isometric hamstring strength test at 90° hip flexion and 20° knee flexion for the dominant and non-dominant legs (ISH 90/20-D and ISH 90/20-ND) (Matinlauri et al., 2019), and the Isometric Belt Squat Test (IBSQT) (Varela-Olalla et al., 2024). Both tests were conducted using force platforms (VALD Performance®, Brisbane, Australia) following standardised procedures. Players performed two maximal voluntary contractions of 5 s duration, with 20 s of recovery between attempts. Participants were instructed to apply force as rapidly and explosively as possible from the moment tension was applied to the belt or strap, maintaining the trunk as vertical as possible, with standardised verbal encouragement provided to promote maximal effort. The variables analysed were maximal force in the dominant and non-dominant legs (ISH 90/20-D and -ND), relative force normalised to BM in both legs (ISH 90/20rel-D and -ND), and maximal and relative force in the Isometric Belt Squat Test (IBSQT and IBSQT PF/BM).

Linear Speed (10 m and 30 m Sprint Tests)

Sprint tests over 10 and 30 m were used to assess acceleration capacity and maximal sprinting speed in football players (Villaseca-Vicuña, Molina-Sotomayor, et al., 2021). Prior to testing, each player completed a specific warm-up consisting of five progressive 30 m sprints. After the warm-up, players performed three maximal 30 m sprint trials, with three minutes of recovery between attempts. Testing was conducted on a natural grass pitch in the morning, under environmental conditions of approximately 17 °C and 54% relative humidity. Sprints were initiated from a standing position, with the front foot placed immediately behind a line located 0.5 m before the first timing gate to avoid interference of the trunk, arms, or head with the laser beam at the start. Three photocell timing gates (Microgate®, Bolzano, Italy) were positioned at 0, 10, and 30 m. Split times for 0–10 m (T10) were recorded as an indicator of acceleration, and 0–30 m times (T30) as an indicator of maximal sprint speed. To assess test reliability, the intraclass correlation coefficient (ICC) and coefficient of variation (CV) were calculated, yielding values of 0.87 and 6.12% for T10, and 0.98 and 5.48% for T30, respectively. The best T30 performance was used for analysis.

Lower-Limb Power (Countermovement Jump)

The countermovement jump (CMJ), frequently used to assess lower-limb power in female football players (Villaseca-Vicuña et al., 2021), was performed following the protocol described by Harry et al. (2024). Prior to testing, each player completed a specific warm-up consisting of 8 minutes of dynamic mobility, five jumps onto a 40 cm box and 2 CMJ. Participants then performed three CMJ trials, with 20 s of recovery between attempts. Players began from an upright standing position with hands on hips to eliminate arm swing, then performed a rapid knee flexion to approximately 90°, and immediately executed a vertical jump with the instruction to reach maximal height. Verbal encouragement was provided to maximise force production. Jump height was calculated using the impulse–momentum equation, and the final result corresponded to the mean of the three trials. This test has been widely applied in women’s football (McMahon et al., 2017; Villaseca-Vicuña, Molina-Sotomayor, et al., 2021). Reliability analysis yielded an ICC of 0.89 and a CV of 7.12%. Measurements were conducted using force platforms (VALD Performance®, Brisbane, Australia).

Intermittent Endurance (30–15 Intermittent Fitness Test)

Intermittent endurance was assessed using the 30–15 Intermittent Fitness Test (30–15 IFT), developed by Buchheit (2008). The protocol consists of 30 s shuttle runs between two lines separated by 40 m, followed by 15 s of active recovery, during which participants walk to the next starting line and wait for the next sign. The initial running speed is 10 km·h⁻¹ and increases progressively by 0.5 km·h⁻¹ per stage until the player is unable to maintain the pace dictated by the audio signal. The variables obtained were: a) the final velocity reached during the test (VIFT); b) estimated maximal oxygen uptake (VO₂max), calculated from VIFT using the equation proposed by the author (Buchheit, 2008).

Competitive Kinematic Performance

External Load Monitoring Using GPS

External load was analysed using several indicators recorded during ten official league matches: total distance covered (TD), high-speed running distance (HSR, > 18 km·h⁻¹), distance of sprints (SPRINT, > 21 km·h⁻¹), number of accelerations (ACC, ≥ 3 m·s⁻²) and decelerations (DEC, ≤ -3 m·s⁻²), maximal speed (MS), PlayerLoad™ (PL), and high metabolic load distance (HMLD; > 25.5 W·kg⁻¹). These indicators allowed for a detailed characterisation of competitive external load and its association with players’ physical profiles (Villaseca-Vicuña, Otero-Saborido, et al., 2021). Measurements were obtained using WIMU® global positioning devices (RealTrack Systems, Almería, Spain) operating at a sampling frequency of 10 Hz.

Statistical Analysis

Descriptive statistics (mean and standard deviation) were calculated for all variables according to playing position. To identify differences between positions, one-way analysis of variance (ANOVA) was performed when assumptions of normality and homogeneity of variances were met. When significant differences were detected, Bonferroni post hoc tests were applied to determine between-position differences. Effect size was calculated using partial eta squared (η^2), with the following thresholds for interpretation: < 0.01 = trivial; 0.01–0.059 = small; 0.06–0.139 = moderate; ≥ 0.14 = large (Cohen, 1988). Correlation analyses between body composition, physical fitness, and competitive external load variables were conducted using Pearson’s correlation coefficient when normality assumptions were met, and Spearman’s rank correlation coefficient otherwise. Statistical significance was set at $p < 0.05$. All analyses were performed using IBM SPSS Statistics (v29.0; IBM Corp., Armonk, NY, USA), and figures were generated using GraphPad Prism (v10; GraphPad Software, San Diego, CA, USA).

Results

Table 1 presents the comparison of body composition variables across playing positions. Significant differences were observed in BM ($p = 0.035$; $\eta^2 = 0.420$, large effect), with GK exhibiting higher values compared with CB, FB, MF, and FW. For the remaining variables (HT, %FM, %MM, and $\Sigma 6SF$), no statistically significant differences were found ($p > 0.05$); however, effect sizes suggest relevant trends.

Table 1. Comparison of body composition according to playing position

Variables	Goalkeepers (n = 3)	Centre-backs (n = 4)	Full-backs (n = 4)	Midfielders (n = 6)	Forwards (n = 6)	pvalue	η^2
BM (kg)	72.50 ± 7.40 ^{bcd}	65.00 ± 6.40	61.25 ± 3.11	59.76 ± 6.61	61.90 ± 2.23	0.035*	0.420
HT (cm)	171.53 ± 3.10	169.40 ± 2.80	167.70 ± 3.04	164.40 ± 10.40	169.40 ± 1.60	0.449	0.177
%FM	28.63 ± 1.60	26.00 ± 2.72	25.40 ± 1.90	25.36 ± 1.95	25.80 ± 1.49	0.216	0.263
%MM	48.16 ± 1.30	47.50 ± 2.43	46.40 ± 1.55	46.56 ± 2.19	45.80 ± 1.34	0.509	0.160
$\Sigma 6SF$ (mm)	72.50 ± 28.20	59.50 ± 8.99	56.70 ± 6.60	58.10 ± 9.29	54.60 ± 8.77	0.407	0.190

Note. Values are presented as mean ± standard deviation. Superscript letters indicate significant differences between playing positions ($p < 0.05$). Superscript letters next to the goalkeepers’ values indicate significant differences compared with the corresponding playing positions: ^b = Centre-backs; ^c = Full-backs; ^d = Midfielders; ^e = Forwards. * $p < 0.05$.

Abbreviations: BM: body mass; HT: height; %FM: percentage of fat mass; %MM: percentage of muscle mass; $\Sigma 6SF$: sum of six skinfolds.

Table 2 shows the comparisons of physical fitness variables across playing positions. Significant differences were observed only for T30 ($p = 0.028$; $\eta^2 = 0.425$, large effect), with FW recording the fastest times. For the remaining variables (MPV, 1RM, RS, ISH, IBSQT, CMJ, and VIFT), no statistically significant differences were found ($p > 0.05$); however, effect sizes were predominantly moderate to large ($\eta^2 = 0.10$ – 0.32), suggesting relevant positional trends.

Table 2. Comparison of physical fitness according to playing position

Variables	Goalkeepers (n = 3)	Centre-backs (n = 4)	Full-backs (n = 4)	Midfielders (n = 6)	Forwards (n = 6)	pvalue	η^2
MPV50 (m·s ⁻¹)	0.96 ± 0.07	1.08 ± 0.12	1.17 ± 0.12	1.07 ± 0.15	1.04 ± 0.15	0.367	0.213
MPV60 (m·s ⁻¹)	0.85 ± 0.01	0.94 ± 0.06	0.96 ± 0.06	0.91 ± 0.09	0.90 ± 0.03	0.230	0.268
MPV70 (m·s ⁻¹)	0.69 ± 0.11	0.83 ± 0.07	0.80 ± 0.06	0.77 ± 0.07	0.80 ± 0.02	0.143	0.318
MPV85 (m·s ⁻¹)	0.54 ± 0.24	0.73 ± 0.08	0.63 ± 0.07	0.62 ± 0.06	0.64 ± 0.07	0.289	0.242
1RM (kg)	119.60 ± 15.30	116.0 ± 14.00	111.0 ± 15.30	100.0 ± 15.81	117.6 ± 17.86	0.330	0.226
RS (1RM/BM)	1.67 ± 0.34	1.78 ± 0.06	1.80 ± 0.17	1.68 ± 0.27	1.58 ± 0.82	0.947	0.038
ISH 90/20-D (N)	431.80 ± 157.00	450.12 ± 74.0	442.8 ± 78.4	409.1 ± 52.8	386.2 ± 117.5	0.828	0.076
ISH 90/20-ND (N)	400.00 ± 122.60	454.43 ± 94.0	413.1 ± 39.5	403.00 ± 69.7	377.29 ± 95.6	0.735	0.100
ISH 90/20rel-D (N·kg ⁻¹)	5.95 ± 2.18	6.90 ± 0.71	7.20 ± 0.96	6.88 ± 0.97	6.23 ± 1.88	0.712	0.106
ISH 90/20rel-ND (N·kg ⁻¹)	5.57 ± 1.92	6.94 ± 0.94	6.74 ± 0.41	6.78 ± 1.15	6.08 ± 1.51	0.544	0.150
IBSQT Peak Force (N)	3602.00 ± 345.80	3908.00 ± 595.00	3270.00 ± 792.50	3252.00 ± 673.00	3849.60 ± 642.48	0.372	0.201
IBSQT PF/BM (N·kg ⁻¹)	50.07 ± 7.54	59.90 ± 4.45	53.28 ± 11.70	54.60 ± 11.10	62.19 ± 10.39	0.384	0.197
T10 (s)	–	1.90 ± 0.07	1.87 ± 0.04	1.91 ± 0.08	1.82 ± 0.10	0.287	0.205
T30 (s)	–	4.62 ± 0.10 ^{abc}	4.46 ± 0.08 ^{ac}	4.58 ± 0.13 ^c	4.33 ± 0.19	0.028*	0.425
CMJ (cm)	30.10 ± 8.18	30.90 ± 3.70	32.70 ± 1.00	29.40 ± 2.37	32.33 ± 3.90	0.645	0.123
VIFT 30–15 (km·h ⁻¹)	–	18.20 ± 0.50	17.75 ± 0.95	18.30 ± 1.08	18.00 ± 1.26	0.827	0.053
VO ₂ max (ml·kg ⁻¹ ·min ⁻¹)	–	47.17 ± 2.80	48.81 ± 1.39	48.80 ± 3.33	47.83 ± 3.07	0.779	0.064

Note. Values are presented as mean ± standard deviation. Superscript letters indicate significant differences between playing positions ($p < 0.05$). Superscript letters indicate significant differences compared with the forwards' group: ^c = Centre-backs; ^d = Full-backs; ^e = Midfielders. The symbol “–” indicates that the variable was not assessed for that position.

Abbreviations: MPV50–MPV85: mean propulsive velocity during the squat exercise at 50%, 60%, 70%, and 85% of one-repetition maximum (m·s⁻¹); 1RM: estimated one-repetition maximum in the squat exercise (kg); RS (1RM/BM): relative strength, calculated as the ratio between one-repetition maximum and body mass; BM: body mass (kg); ISH 90/20-D: maximal isometric hamstring strength assessed at 90° hip flexion and 20° knee flexion in the dominant leg (N); ISH 90/20-ND: maximal isometric hamstring strength assessed at 90° hip flexion and 20° knee flexion in the non-dominant leg (N); ISH 90/20rel-D: relative maximal isometric hamstring strength (dominant leg), expressed as force normalized to body mass (N·kg⁻¹); ISH 90/20rel-ND: relative maximal isometric hamstring strength (non-dominant leg), expressed as force normalized to body mass (N·kg⁻¹); IBSQT Peak Force: maximal force obtained during the isometric belt squat test (N); IBSQT PF/BM: relative maximal isometric belt squat force, expressed as force normalized to body mass (N·kg⁻¹); T10: 10 m sprint time (s); T30: 30 m sprint time (s); CMJ: countermovement jump height (cm); VIFT 30–15: final velocity achieved in the 30–15 Intermittent Fitness Test (km·h⁻¹); VO₂max: estimated maximal oxygen uptake (ml·kg⁻¹·min⁻¹).

Table 3 presents the comparisons of competitive external load variables according to playing position, revealing a clear positional pattern, particularly in metrics associated with high-intensity actions. Specifically, FW recorded significantly higher values in HSR, SPRINT, MS, and HMLD ($p < 0.05$), with large effect sizes. In contrast, CB exhibited the lowest values for these variables. FB and MF showed intermediate values, and no significant differences were observed for ACC, DEC, or PL ($p > 0.05$).

Table 3. Comparison of competitive external load according to playing position

Variables	Centre-backs (n = 4)	Full-backs (n = 4)	Midfielders (n = 6)	Forwards (n = 6)	Total (n = 20)	pvalue	η^2
TD (m)	9238.86 ± 387.23 ^{bc}	9930.38 ± 163.13	10261.22 ± 792.97 ^a	10099.30 ± 472.47	9925.40 ± 614.33	0.056	0.387
HSR >18 (m)	596.16 ± 118.72 ^{bc}	993.01 ± 65.33 ^a	848.56 ± 168.49	1112.79 ± 248.25 ^a	909.28 ± 254.29	0.003*	0.590
SPRINT >21 (m)	237.23 ± 88.21 ^c	402.35 ± 52.16	324.76 ± 75.21	543.17 ± 201.93 ^a	391.64 ± 168.98	0.014*	0.498
ACC ≥3 (n)	36.42 ± 4.84	44.17 ± 6.55	37.73 ± 15.45	43.64 ± 7.99	40.68 ± 9.69	0.546	0.128
DEC ≥3 (n)	49.75 ± 4.77	64.50 ± 7.74	66.47 ± 19.69	68.17 ± 6.76	63.07 ± 12.82	0.119	0.315
PL (AU)	119.72 ± 3.66	121.12 ± 10.76	144.14 ± 13.95	122.83 ± 10.20	127.44 ± 18.48	0.123	0.312
MS (km·h ⁻¹)	27.12 ± 0.56 ^c	28.35 ± 1.28	27.51 ± 1.04 ^c	30.01 ± 1.20 ^{ab}	28.40 ± 1.56	0.003*	0.599
HMLD (m)	1288.12 ± 135.64 ^c	1655.67 ± 82.56	1635.99 ± 364.66	1796.09 ± 220.29 ^a	1617.45 ± 287.04	0.035*	0.427

Note. Values are presented as mean ± standard deviation. Superscript letters indicate significant differences between playing positions ($p < 0.05$); superscript letters indicate significant differences compared with the corresponding playing positions: ^a = Full-backs; ^b = Midfielders; ^c = Forwards. * $p < 0.05$. Abbreviations: TD, total distance (m); HSR >18, high-speed running distance performed at speeds > 18 km·h⁻¹ (m); SPRINT >21, sprint distance performed at speeds > 21 km·h⁻¹ (m); ACC ≥3, number of accelerations ≥ 3 m·s⁻² (n); DEC ≥3, number of decelerations ≥ 3 m·s⁻² (n); PL, PlayerLoad™ (arbitrary units); MS, maximal speed (km·h⁻¹); HMLD, high metabolic load distance, defined as distance covered above 25.5 W·kg⁻¹ (m). TD = total distance; HSR = high-speed running distance (> 18 km·h⁻¹); SPRINT = sprint distance (> 21 km·h⁻¹); ACC = accelerations ≥ 3 m·s⁻²; DEC = decelerations ≥ 3 m·s⁻²; PL = PlayerLoad™; MS = maximal speed; HMLD = high metabolic load distance (> 25.5 W·kg⁻¹).

Table 4 shows the correlations between body composition and physical fitness variables. Significant negative relationships were observed between %FM and MPV60 ($r = -0.486$; $p < 0.05$). In addition, $\Sigma 6SF$ was negatively correlated with MPV60 and MPV70 ($r = -0.477$; $p < 0.05$; $r = -0.618$; $p < 0.01$, respectively), as well as with CMJ ($r = -0.494$; $p < 0.05$). No significant correlations were found between the remaining physical fitness variables related to strength, high-speed running, sprint, and intermittent endurance and body composition measures.

Table 4. Correlations between body composition and physical fitness

Variables	HT (cm)	%FM	%MM	$\Sigma 6SF$
MPV50 ($m \cdot s^{-1}$)	-0.121	-0.120	0.146	-0.015
MPV60 ($m \cdot s^{-1}$)	-0.486*	-0.343	-0.030	-0.098
MPV70 ($m \cdot s^{-1}$)	-0.349	-0.430*	-0.123	-0.477*
MPV85 ($m \cdot s^{-1}$)	0.103	-0.218	-0.037	-0.618**
1RM (kg)	0.354	-0.035	0.102	-0.149
RS (1RM/BM)	-0.054	0.105	-0.049	-0.021
ISH 90/20-D (N)	0.255	0.108	-0.144	0.002
ISH 90/20-ND (N)	0.233	0.012	-0.051	-0.106
ISH 90/20rel-D ($N \cdot kg^{-1}$)	-0.073	0.071	-0.350	-0.118
ISH 90/20rel-ND ($N \cdot kg^{-1}$)	-0.122	0.000	-0.276	-0.194
IBSQT Peak Force (N)	0.135	-0.034	0.037	0.193
IBSQT PF/BM ($N \cdot kg^{-1}$)	-0.206	-0.083	-0.190	0.066
T10 (s)	0.029	0.035	0.203	0.238
T30 (s)	-0.008	-0.168	0.301	0.139
CMJ (cm)	0.153	-0.071	-0.007	-0.494*
VIFT 30–15 ($km \cdot h^{-1}$)	-0.077	0.030	0.068	-0.142
VO ₂ max ($ml \cdot kg^{-1} \cdot min^{-1}$)	0.027	-0.040	0.190	-0.275

Note. Correlation coefficients are presented as Pearson's r . MPV50–MPV85: mean propulsive velocity during the squat exercise with progressive loads of 50%, 60%, 70%, and 85% of one-repetition maximum ($m \cdot s^{-1}$); 1RM: estimated one-repetition maximum in the squat exercise (kg); RS (1RM/BM): relative strength, calculated as the ratio between one-repetition maximum and body mass; ISH 90/20-D and ISH 90/20-ND: maximal isometric hamstring strength assessed at 90° hip flexion and 20° knee flexion in the dominant and non-dominant leg (N); ISH 90/20rel-D and ISH 90/20rel-ND: relative maximal isometric hamstring strength, expressed as force normalized to body mass ($N \cdot kg^{-1}$); IBSQT Peak Force: maximal force obtained during the isometric belt squat test (N); IBSQT PF/BM: relative maximal isometric belt squat force, expressed as force normalized to body mass ($N \cdot kg^{-1}$); T10 and T30: 10 m and 30 m sprint times (s); CMJ: countermovement jump height (cm); VIFT 30–15: final velocity achieved in the 30–15 Intermittent Fitness Test ($km \cdot h^{-1}$); VO₂max: estimated maximal oxygen uptake ($ml \cdot kg^{-1} \cdot min^{-1}$); HT: height (cm); %FM: percentage of fat mass; %MM: percentage of muscle mass; $\Sigma 6SF$: sum of six skinfolds (mm). Correlations were considered statistically significant at $p < 0.05$ (*) and $p < 0.01$ (**), two-tailed.

Table 5 presents the correlations between body composition and competitive external load variables. HT was positively associated with ACC ($r = 0.510$; $p < 0.05$). In contrast, $\Sigma 6SF$ was negatively correlated with ACC ($r = -0.579$; $p < 0.01$) and showed negative trends with HSR, SPRINT, and HMLD ($r = -0.373$ to -0.366).

Conversely, %FM, %MM, and the remaining body composition variables did not show significant associations with competitive external load metrics.

Table 5. Correlations between body composition and GPS-derived external load variables

Variables	HT (cm)	%FM	%MM	$\Sigma 6SF$
TD	0.102	0.212	-0.028	-0.064
HSR >18	0.079	-0.080	-0.017	-0.373
SPRINT >21	0.101	-0.176	0.039	-0.366
ACC ≥ 3	0.510*	-0.093	0.124	-0.579**
DEC ≥ 3	0.329	0.078	0.057	-0.266
PL	0.163	-0.022	-0.070	-0.084
MS	0.275	-0.085	-0.103	-0.281
HMLD	0.109	0.069	-0.016	-0.355

Note. Correlation coefficients are presented as Pearson's r . TD: total distance (m); HSR >18: high-speed running distance performed at speeds > 18 $km \cdot h^{-1}$ (m); SPRINT >21: sprint distance performed at speeds > 21 $km \cdot h^{-1}$ (m); ACC ≥ 3 : number of accelerations $\geq 3 m \cdot s^{-2}$ (n); DEC ≥ 3 : number of decelerations $\geq 3 m \cdot s^{-2}$ (n); PL: PlayerLoad™ (arbitrary units); MS: maximal speed ($km \cdot h^{-1}$); HMLD: high metabolic load distance, defined as distance covered above 25.5 $W \cdot kg^{-1}$ (m); HT: height (cm); %FM: percentage of fat mass; %MM: percentage of muscle mass; $\Sigma 6SF$: sum of six skinfolds (mm). Correlations were considered statistically significant at $p < 0.05$ (*) and $p < 0.01$ (**), two-tailed.

Figure 1 illustrates negative associations between $\Sigma 6SF$ and several physical performance variables. Higher $\Sigma 6SF$ values were associated with lower MPV60 ($R^2 = 0.227$; $p = 0.025$) and MPV85 ($R^2 = 0.382$; $p = 0.002$).

Similarly, players with higher $\Sigma 6SF$ exhibited lower CMJ performance ($R^2 = 0.239$; $p = 0.017$) and performed fewer ACC during competition ($R^2 = 0.335$; $p = 0.009$).

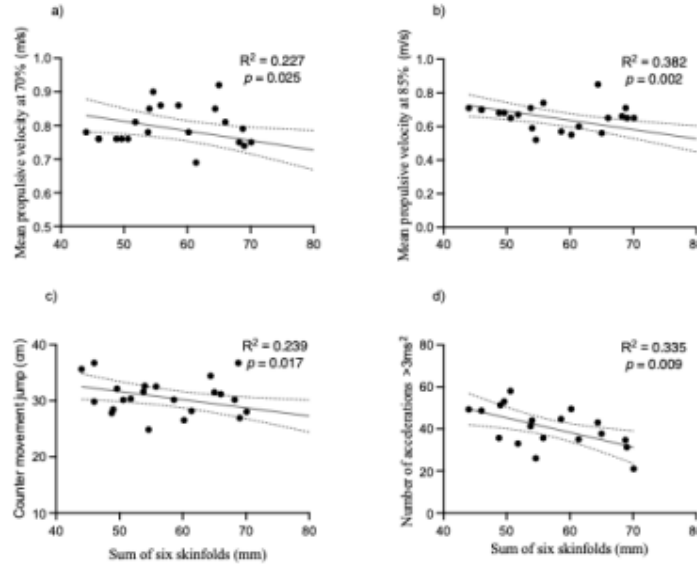


Figure 1. Linear regression between $\Sigma 6SF$ and physical performance variables: (a) mean propulsive velocity during the squat exercise at load 70%, (b) mean propulsive velocity during the squat exercise at load 85%, (c) countermovement jump height, and (d) number of accelerations $> 3 \text{ m} \cdot \text{s}^{-2}$ during competition.

Table 6 presents the correlations between physical fitness variables and competitive performance. Significant negative correlations were observed between 1RM and TD ($r = -0.523$; $p < 0.05$), as well as between ISH 90/20 PEAK FORCE and SPRINT ($r = -0.552$ to -0.642 ; $p < 0.05$ – 0.01). In sprint performance tests, both T10 and T30 were negatively correlated with HSR, SPRINT, and MS ($r = -0.466$ to -0.795 ; $p < 0.05$ – 0.01). Conversely, VIFT and $\text{VO}_{2\text{max}}$ showed positive correlations with TD and HMLD ($r = 0.465$ – 0.545 ; $p < 0.05$).

Table 6. Correlations between physical fitness and competitive external load

Variables	TD	HSR	SPRINT	ACC	DEC	PL	MS	HMLD
MPV50 ($\text{m} \cdot \text{s}^{-1}$)	0.026	0.041	-0.070	0.118	0.201	-0.060	-0.192	0.028
MPV60 ($\text{m} \cdot \text{s}^{-1}$)	-0.478*	-0.041	-0.008	0.081	-0.156	-0.165	-0.166	-0.147
MPV70 ($\text{m} \cdot \text{s}^{-1}$)	-0.465	0.029	0.043	-0.113	-0.129	-0.082	-0.043	-0.125
MPV85 ($\text{m} \cdot \text{s}^{-1}$)	-0.287	-0.239	-0.127	0.136	-0.157	0.170	-0.006	-0.199
1RM (kg)	-0.523*	-0.119	0.109	0.242	-0.126	0.244	0.392	-0.384
RS (1RM/BM)	-0.235	-0.210	-0.110	-0.151	-0.324	0.145	0.222	-0.350
ISH 90/20-D (N)	-0.095	-0.438	-0.552*	-0.079	-0.048	0.412	-0.197	-0.280
ISH 90/20-ND (N)	-0.196	-0.558*	-0.607**	-0.041	-0.017	0.196	-0.253	-0.407
ISH 90/20rel-D ($\text{N} \cdot \text{kg}^{-1}$)	0.098	-0.336	-0.530*	-0.164	-0.015	0.403	-0.246	-0.124
ISH 90/20rel-ND ($\text{N} \cdot \text{kg}^{-1}$)	0.003	-0.501*	-0.642**	-0.133	0.030	0.182	-0.337	-0.272
IBSQT Peak Force (N)	-0.557*	-0.210	0.003	-0.310	-0.373	0.197	0.236	-0.470*
IBSQT PF/BM ($\text{N} \cdot \text{kg}^{-1}$)	-0.393	-0.062	0.106	-0.411	-0.371	0.146	0.246	-0.315
T10 (s)	0.320	-0.466*	-0.623**	-0.450	-0.062	0.156	-0.538*	-0.233
T30 (s)	-0.012	-0.710**	-0.795**	-0.430	-0.204	-0.001	-0.692**	-0.495*
CMJ (cm)	-0.099	0.342	0.395	0.322	0.171	0.149	0.433	0.203
VIFT 30–15 ($\text{km} \cdot \text{h}^{-1}$)	0.492*	0.364	0.187	-0.177	0.063	0.085	-0.159	0.465*
$\text{VO}_{2\text{max}}$ ($\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$)	0.484*	0.440	0.277	0.085	0.196	0.108	-0.123	0.545*

Note. Correlation coefficients are presented as Pearson's r . MPV50–MPV85: mean propulsive velocity during the squat exercise with progressive loads of 50%, 60%, 70%, and 85% of one-repetition maximum ($\text{m} \cdot \text{s}^{-1}$); 1RM: estimated one-repetition maximum in the squat exercise (kg); RS (1RM/BM): relative strength, calculated as the ratio between one-repetition maximum and body mass; ISH 90/20-D and ISH 90/20-ND: maximal isometric hamstring strength assessed at 90° hip flexion and 20° knee flexion in the dominant and non-dominant leg (N); ISH 90/20rel-D and ISH 90/20rel-ND: relative maximal isometric hamstring strength, expressed as force normalized to body mass ($\text{N} \cdot \text{kg}^{-1}$); IBSQT Peak Force: maximal force obtained during the isometric belt squat test (N); IBSQT PF/BM: relative maximal isometric belt squat force, expressed as force normalized to body mass ($\text{N} \cdot \text{kg}^{-1}$); T10 and T30: 10 m and 30 m sprint times (s); CMJ: countermovement jump height (cm); VIFT 30–15: final velocity achieved in the 30–15 Intermittent Fitness Test ($\text{km} \cdot \text{h}^{-1}$); $\text{VO}_{2\text{max}}$: estimated maximal oxygen uptake ($\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$); TD: total distance (m); HSR: high-speed running distance ($> 18 \text{ km} \cdot \text{h}^{-1}$, m); SPRINT: sprint distance ($> 21 \text{ km} \cdot \text{h}^{-1}$, m); ACC: number of accelerations $\geq 3 \text{ m} \cdot \text{s}^{-2}$ (n); DEC: number of decelerations $\geq 3 \text{ m} \cdot \text{s}^{-2}$ (n); PL: PlayerLoad™ (arbitrary units); MS: maximal speed ($\text{km} \cdot \text{h}^{-1}$); HMLD: high metabolic load distance, defined as distance covered above $25.5 \text{ W} \cdot \text{kg}^{-1}$ (m). Correlations were considered statistically significant at $p < 0.05$ (*) and $p < 0.01$ (**), two-tailed.

Figure 2 illustrates significant associations between linear sprint performance and distances covered at different running intensities during official competition. Shorter T10 was associated with greater HSR, SPRINT, and MS ($R^2 = 0.197$ – 0.267 ; $p < 0.05$). Similarly, T30 showed negative associations with HSR and SPRINT ($R^2 =$

0.472–0.602; $p \leq 0.001$). In addition, VIFT was positively associated with HSR and SPRINT during competition ($R^2 = 0.215$ – 0.240 ; $p < 0.05$).

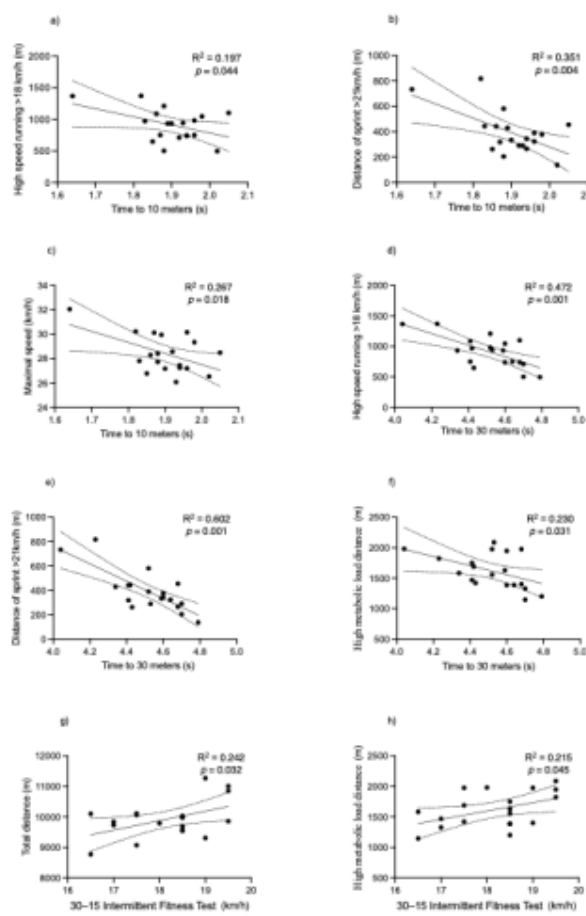


Figure 2. Linear regression between running speed variables and physical performance during competition: 10 m sprint time with (a) distance covered $> 18 \text{ km} \cdot \text{h}^{-1}$, (b) distance covered $> 21 \text{ km} \cdot \text{h}^{-1}$, and (c) maximal speed; 30 m sprint time with (d) distance covered $> 18 \text{ km} \cdot \text{h}^{-1}$, (e) distance covered $> 21 \text{ km} \cdot \text{h}^{-1}$, and (f) high metabolic load distance; and VIFT 30–15 with (g) total distance and (h) high metabolic load distance.

Discussion

The aim of this study was to compare body composition, physical fitness profiles, and GPS-derived competitive locomotor performance in professional female football players according to the playing position, and to investigate the associations between body composition and physical fitness profiles, and the locomotor external load during competition. The main findings indicate significant positional differences in body composition and physical fitness, as well as meaningful associations between these variables and GPS-derived external load during competition.

Regarding body composition, significant differences in body mass were observed according to playing position ($p = 0.035$; $\eta^2 = 0.420$, large effect), with goalkeepers presenting higher values than outfield players. This finding is consistent with previous research in women's football, where goalkeepers typically exhibit a distinct morphological profile characterised by greater height and body mass (Villasaca-Vicuña et al., 2021). Although no statistically significant differences were identified for fat mass percentage, muscle mass percentage, or the sum of six skinfolds, effect sizes were large ($\eta^2 = 0.160$ – 0.263), suggesting relevant positional trends. These results align with those reported by Vescovi et al. (2011, 2021), who highlighted that morphological differences between positions reflect functional adaptations to the specific demands of the game, with goalkeepers being more robust and outfield players relatively leaner. Similarly, recent studies in Chilean women's football have shown that fat mass and muscle mass percentages are associated with performance in speed, jump, and intermittent endurance tests, reinforcing the relevance of anthropometric profiles as performance-related indicators (Villasaca-Vicuña et al., 2021). Collectively, the evidence supports the need to establish positional morphofunctional profiles in professional women's football to guide training planning, injury prevention, and position-specific physical preparation (Mujika et al., 2018).

In terms of physical fitness, significant differences were observed only for 30 m sprint performance (T30) ($p = 0.028$; $\eta^2 = 0.425$, large effect), with forwards recording the fastest times, confirming the high sprint demands associated with this position. Although no significant differences were found in the remaining variables (mean propulsive velocity, 1RM, maximal isometric strength, CMJ, and VIFT), effect sizes ranged from moderate to large ($\eta^2 = 0.10$ – 0.32), indicating meaningful positional tendencies with potential practical applications for training design. These findings are consistent with previous literature, in which forwards and midfielders generally outperform other positions in speed and jump tests, whereas defenders and goalkeepers tend to demonstrate greater absolute maximal strength (Vescovi et al., 2006; Villaseca-Vicuña et al., 2021). Moreover, recent studies in Chilean female players have reported associations between jump ability, linear speed, and intermittent endurance irrespective of playing position, reinforcing the importance of integrating functional testing with external load data to characterise performance in women's football (Villaseca-Vicuña et al., 2021). Overall, these results suggest that even when positional differences in physical fitness do not reach statistical significance, the magnitude of the effects and their consistency with position-specific demands justify an individualised approach to training.

GPS-derived external load variables revealed a clear positional pattern, particularly in high-intensity metrics, with forwards exhibiting higher values for high-speed running, sprinting, maximal speed, and high metabolic load distance, accompanied by large effect sizes. These findings are consistent with previous evidence reported within the present manuscript, indicating that players with superior speed and power capacities tend to experience greater high-intensity locomotor demands during competition (Villaseca-Vicuña et al., 2021a; 2021b). Conversely, centre-backs displayed the lowest values for these variables, in line with a more conservative locomotor profile associated with their tactical role (Villaseca-Vicuña et al., 2024). Although full-backs and midfielders showed intermediate values and did not consistently reach statistical significance, moderate to large effect sizes suggest relevant high-intensity demands. The lack of statistical significance in some comparisons may be explained by the relatively small sample size and the contextual variability of tactical roles (Vescovi & Falenchuk, 2019), as these positions frequently alternate between offensive and defensive functions depending on the team's playing model, thereby influencing external load expression (Villaseca-Vicuña et al., 2024b). With respect to the relationships between body composition and physical fitness, fat mass percentage was negatively correlated with mean propulsive velocity at 60% of 1RM, while the sum of six skinfolds showed negative associations with mean propulsive velocity at moderate-to-high loads and with CMJ performance. These findings suggest that higher levels of adiposity negatively affect the ability to produce movement velocity under load, which is a key determinant of competitive performance (González-Badillo & Sánchez-Medina, 2010). Previous studies have demonstrated that lower fat mass and higher muscle mass are associated with superior sprint and jump performance in female football players (Letelier-Acevedo et al., 2024; Villaseca-Vicuña et al., 2021). Accordingly, monitoring skinfold thickness and fat mass percentage represents a practical tool for optimising physical preparation, as elevated values may compromise neuromuscular efficiency and limit power output during high-intensity actions (Emmonds et al., 2019).

Regarding the associations between body composition and competitive external load, the results showed that the sum of six skinfolds was negatively associated with indicators of high-intensity actions, particularly accelerations, and exhibited negative trends with high-speed running, sprinting, and high metabolic load distance. These findings suggest that higher adiposity may limit the ability to perform explosive actions during competition, which is consistent with evidence from Chilean first-division female football players, where body composition was related to locomotor performance and power production (Letelier-Acevedo et al., 2024; Villaseca-Vicuña et al., 2021). These results further highlight the importance of systematic body composition monitoring, as excessive fat mass may impair locomotor efficiency and performance in high-intensity actions that are critical to competitive success in women's football (Emmonds et al., 2019; Mujika et al., 2018).

Regarding the correlations between physical fitness and competitive external load, the results showed that physical capacities were differentially associated with locomotor performance during match play. This observation aligns with previous findings from the same research group, where players with higher 1RM values tended to engage in more position-specific actions with lower overall locomotor volume, likely influenced by tactical role and spatial positioning (Villaseca-Vicuña et al., 2021). Similarly, isometric strength measures were negatively correlated with high-speed running and sprinting, indicating that static force production capacity alone does not directly predict explosive locomotor performance in competition. This apparent discrepancy may be explained by the high neuromuscular specificity of sprinting and high-speed actions, which depend more on the ability to apply force rapidly (rate of force development) and on intermuscular coordination than on maximal or isometric strength per se (González-Badillo et al., 2011; Torres-Torrelo et al., 2017).

In contrast, linear sprint performance (T10 and T30) was negatively associated with high-speed running, sprinting, and maximal speed, demonstrating that players who perform better in sprint tests also experience greater high-speed locomotor demands during matches (Villaseca-Vicuña et al., 2021). Furthermore, performance in the 30–15 Intermittent Fitness Test and estimated $\dot{V}O_{2\max}$ were positively associated with total distance covered and high metabolic load distance, confirming their usefulness as indicators of football-specific aerobic capacity, as previously reported in female football players (Letelier-Acevedo et al., 2024).

Several limitations should be considered when interpreting the findings of this study. First, the relatively small sample size ($n = 23$) limits the generalisability of the results, although it reflects the typical squad size in professional women's football. Second, the data were obtained from a single professional club, which may restrict the diversity of playing styles and physical profiles, and limit extrapolation to other competitive contexts. Third, the cross-sectional design precludes causal inference, allowing only the identification of associations between variables. Finally, although 10 Hz GPS devices are widely validated, some limitations in accurately capturing short sprints and high-intensity changes of direction may exist.

The findings of this study provide relevant insights for training planning and monitoring in professional women's football. Fat mass percentage showed negative associations with mean propulsive velocity, CMJ performance, and accelerations, highlighting the importance of systematic body composition monitoring as a performance-related indicator. Forwards demonstrated superior 30 m sprint performance, reinforcing the need for position-specific training programmes that prioritise speed and power development. The positive associations between VIFT, VO₂max, total distance, and high metabolic load distance support the use of the 30–15 IFT as a practical field test to estimate football-specific aerobic capacity and predict competitive performance. Although maximal and isometric strength were not positively associated with locomotor performance, they remain essential for injury prevention and joint stability and should therefore be considered within a comprehensive physical preparation framework.

Conclusions

The results of this study demonstrate the existence of positional differences in body composition, physical fitness, and competitive external load in professional women's football players. Goalkeepers exhibited higher body mass, whereas forwards stood out in speed-related variables, both in physical tests and in high-intensity GPS-derived metrics. Competitive external load showed a clear positional pattern, with greater high-speed locomotor demands for forwards and lower demands for centre-backs. Correlational analyses indicated that higher fat mass percentage is negatively associated with physical performance and explosive actions during competition, while sprint speed and intermittent endurance are positively related to external load. Overall, these findings highlight the importance of integrating morphofunctional assessments, physical fitness testing, and GPS monitoring to achieve a comprehensive understanding of performance in professional women's football.

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