



Locomotor activities of female football players: analysis of training and competition

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ABSTRACT

Purpose. In female football, a growing concern has emerged regarding assessing and monitoring strategies, particularly on locomotor activities. This study evaluated locomotor activities during training sessions and official matches of female football players according to their field position.

Methods. Twenty-four semi-professional female football players aged 20.1 ± 3.4 years were included in the analysis: five central defenders, four wide defenders, seven central midfielders, four wingers, and four forwards. Data collection included 105 training sessions and 26 official matches. The Global Positioning System examined distance variables, accelerations, and decelerations actions.

Results. Significant differences were observed in training sessions for total distance ($p < 0.01$). Wingers (5.60 ± 1.44 km) and wide defenders (5.42 ± 1.35 km) covered significantly greater total distances compared to the other field positions. During official matches, differences in players' locomotor activities were more evident among field positions, particularly in sprinting ($p < 0.01$), and in the number of accelerations and decelerations ($p < 0.01$). Central defenders showed more distance covered in sprinting (77.8 ± 64.9 m), while wide defenders presented greater acceleration (44.3 ± 23.0) and deceleration actions (57.2 ± 26.5).

Conclusions. Data on players' locomotor activities based on field position might help understand players' profiles. This information is useful to guide clubs and coaching staff in the player recruitment process, and to support a better organisation of the training plan.

Key words: soccer, external load, intensity, GPS, monitoring, match

Introduction

In the past 10 years, the growth of female football has been significant, leading to an increased number of players registered, competitions available, and professionalisation status [1]. Therefore, given the interest in learning more about locomotor activity in training and competition, standard monitoring strategies have been progressively adopted. These include tracking systems that monitor players' locomotor activities that might provide helpful data to improve the team's prep-

aration processes [2]. Frequently, Global Positioning Systems (GPS) are used for this purpose. These instruments make it possible to gather data regarding the players' speed, and distance covered, as well as changes in velocity measures such as accelerations and decelerations.

In the football literature, a significant body of research has been developed to examine players' locomotor activities both in training and competition, particularly in male players [3, 4]. Among female footballers, a growing concern has emerged in assessing and moni-

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toring strategies, and helping coaches design appropriate training plans. Although previous research has been designed to evaluate players' locomotor activities in female football [5–8], there is still a significant gap between sexes. Indeed, sex differences in locomotor activities have been previously described during competition, since male players covered more distance in total and at higher speed thresholds [9]. Additionally, females' maximum sprint velocity is nearly 10% lower than male football players over short distances [10]. The evidence in the literature demonstrates that female footballers present lower physical capacities than their male counterparts across a range of fitness attributes, highlighting the importance of analysing female players' locomotor activities based on sex-specific thresholds [11].

Regarding locomotor activities, most of the research developed in female football has focused on match performance. A study conducted on 17 elite female players has described overall total distance values ranging from 9.7 ± 1.4 km and 9.9 ± 1.8 km in national and international matches, respectively [5]. In another study among 25 collegiate Division II players, a total distance value of 5.5 ± 2.4 km was reported during the match analysis [6]. On the other hand, some researchers have assessed players' locomotor activities based on field position [7, 8]. For instance, in a sample of 12 elite players, midfielders and wingers presented greater total distances covered (10.6 ± 0.2 km and 10.5 ± 0.8 km, respectively). In contrast, wingers and forwards showed superior sprinting distances (850 ± 178 m and 841 ± 238 m, respectively) [7]. Similar results were reported in NCAA Division III players, with midfielders presenting the highest total distance covered (10.6 ± 0.5 km) and wingers demonstrating the greater sprinting distance (403 ± 258 m) [8]. Indeed, examining players' locomotor activities based on field position is of great interest to the coaching staff, providing a better understanding of players' profiles and helping to provide an adequate training prescription.

In the meantime, analysing training units might provide important insights into the training process. For instance, past research has observed differences across playing positions in matches and training microcycles, underlining the lack of position specificity in common training sessions adopted by coaches in elite male football [12]. Another study reported a mean total distance of almost double in matches compared to training units (5.48 ± 2.35 km and 2.95 ± 0.95 km, respectively) [6]. When analysing field positions, the authors described that external load was greater among forwards, midfielders, and central defenders. However,

during training sessions, data on external load variables was similar between playing positions [13]. These differences between training and game contexts lead us to believe there is still a long way to go regarding creating more suitable training situations for what will happen in the matches.

Overall, there is still a significant gap in knowledge regarding the locomotor activities of female footballers in training and competition. This knowledge is of great interest both for the practitioners and coaching staff, contributing to a better organisation of the training plan. Therefore, this study aimed to assess locomotor activities during training sessions and official matches of female football players according to their field position. Based on previous studies [7, 8, 13], it was hypothesised that (1) there are significant differences concerning players' locomotor activities both in training and matches, and (2) match demands elicit greater locomotor activities compared to training sessions. In the first hypothesis, it would be expected that midfielders would present greater total distances covered compared to the other field positions both in training sessions and matches. In the second hypothesis, it would be predicted that players' locomotor activities (i.e., distances and running variables, accelerations, and decelerations) would be superior during matches compared to training units.

Material and methods

Study design

This prospective study was conducted during the 2021/2022 season. Data collection spanned from September 2021 to June 2022, including one team, 105 training sessions and 26 official matches. Typically, players had four training sessions per week (mean duration of 90 min) and two to three official matches per month. At the time, the team was competing in the main Portuguese League (Liga BPI). The matches lasted ~90 min, separated by two halves of ~45 min.

Participants

This study included 24 semi-professional female football players aged 20.1 ± 3.4 years (stature: 165.2 ± 5.8 cm; body mass: 60.1 ± 7.3 kg): five central defenders, four wide defenders, seven central midfielders, four wingers, and four forwards. Twenty-two players had their right foot as dominant and two had their left foot as dominant. In this study, only the players that completed at least 85% of the training sessions were in-

cluded. During the season, the data from players who were injured was not considered in the analysis. The match assessment included only the players who were on the field for 60 or more minutes. The goalkeepers were the only position excluded.

Body composition

Stature and body mass were assessed at the beginning of the season. Stature was measured using a portable stadiometer (SECA 213, Hamburg, Germany) to the nearest 0.1 cm. Body mass was evaluated using a portable scale (SECA 760, Hamburg, Germany) to the nearest 0.1 kg. All measurements were conducted with the participants barefoot during the early morning.

Locomotor activity

Players' movements were recorded during each training session and official match using a 10-Hz GPS unit (Apex Pro Series, STATSports, Northern Ireland), whose validity was previously reported [14]. The device features a 100 Hz gyroscope, a 100 Hz tri-axial accelerometer, and a 10 Hz magnetometer. The GPS units were placed in manufacturer-provided vests on the players' backs between the scapulae and activated nearly 15 min before the training session/match. The GPS units were placed in a clear outdoor space to ensure proper satellite connection, and the calibration procedures followed the manufacturer's guidelines. To avoid potential inter-unit variation, the players used the same GPS unit for each training session/match [15]. For analysis, the data files collected were managed and downloaded from the manufacturer's software (Apex Pro Series Sonra 4.0).

Locomotor activities were analysed based on previous reports on female footballers [11, 16]: standing and walking (0–6.0 km/h), jogging (6.1–8.0 km/h), low-intensity running (8.1–12.0 km/h), moderate-intensity running (12.1–15.5 km/h), and high-intensity running (15.6–20 km/h), sprinting (> 20 km/h), accelerations ($\geq 2 \text{ m/s}^2$), decelerations ($\leq 2 \text{ m/s}^2$), and total distance. Each player was entered independently into the database to characterise their locomotor activities according to the player's position, both in training situations and matches. The analysis of training sessions included 305 central defender, 229 wide defender, 383 central midfielder, 222 winger, and 261 forward observations. For match analysis, 65 central defender, 66 wide defender, 98 central midfielder, 66 winger, and 67 forward observations were considered. The optimal sample size calculation was performed using

G*Power 3.1 [17] based on the number of observations. For five groups analyses, an a priori one-way between-group analysis of variance indicated a total sample size of 200 observations to achieve 80% power to detect an effect size of 0.25 at a 0.05 level of significance. This indicates at least 40 observations in each group.

Statistical analysis

Descriptive statistics are presented as mean \pm standard deviation and were used to characterise the locomotor activities. The normality of the data was verified using the Kolmogorov–Smirnov test. The Kruskal–Wallis Test was performed to analyse differences in body composition between field positions. A one-way between-group analysis of variance (ANOVA) and post hoc comparisons using the Tukey HSD test were conducted to explore differences in GPS variables according to field position, both in training and competition. Previously, preliminary analyses were carried out to ensure the principles of normality, linearity, and homogeneity of variance. All analyses were performed using the Statistical Package for the Social Sciences version 28.0 (IBM SPSS, Chicago, USA). The significance level was set at 0.05.

Results

Table 1 presents the descriptive age and body composition statistics according to field positions. Overall, the forwards were taller and heavier when compared to their peers.

Table 2 summarises the descriptive statistics and the comparison results between field positions regarding training sessions. A total of 1,400 observations were analysed over 105 training units. Statistically significant differences between groups were detected in the sprinting ($F = 2.391$, $p = 0.05$, small effect size), total distance ($F = 4.502$, $p < 0.01$, small effect size), and top speed ($F = 22.245$, $p < 0.01$, moderate effect size) variables. In sprinting distance covered, the central midfielders presented the highest mean values ($25.5 \pm 42.0 \text{ m}$) followed by the forwards ($21.1 \pm 37.4 \text{ m}$). In contrast, the central defenders ($17.8 \pm 34.2 \text{ m}$) and wide defenders ($17.9 \pm 37.7 \text{ m}$) displayed lower mean scores in sprinting actions. The wingers ($5.60 \pm 1.44 \text{ km}$) and wide defenders ($5.42 \pm 1.35 \text{ km}$) covered the highest total distances, while the forwards showed lower mean values ($5.08 \pm 1.27 \text{ km}$). Significantly lower top speed values ($21.9 \pm 2.5 \text{ km/h}$) were displayed by the central midfielders compared to their peers. Although not statistically significant, the central mid-

Table 1. Descriptive statistics for age and body composition according to players' positions

Variables	Wide defenders (n = 4) mean ± SD	Central defenders (n = 5) mean ± SD	Central midfielders (n = 7) mean ± SD	Wingers (n = 4) mean ± SD	Forwards (n = 4) mean ± SD
Age (years)	20.3 (18.7–21.7)	19.0 (17.0–27.9)	18.7 (17.7–21.5)	20.3 (17.4–29.4)	19.2 (16.4–25.9)
Stature (cm)	163.0 (161.0–166.0)	170.0 (160.0–175.0)	158.0 (156.0–166.0)	165.5 (159.0–167.0)	170.0 (163.0–176.0)
Body mass (kg)	58.4 (55.3–60.1)	60.2 (53.6–63.0)	56.1 (47.1–65.5)	61.7 (59.0–64.6)	67.7 (63.1–80.9)

Table 2. Descriptive statistics and results of the comparison between players' positions regarding training sessions.

Variables	Wide defenders (n = 229) mean ± SD	Central defenders (n = 305) mean ± SD	Central midfielders (n = 383) mean ± SD	Wingers (n = 222) mean ± SD	Forwards (n = 261) mean ± SD	ANOVA	
						F	p
Walking (m)	1005.9 ± 196.9	1037.9 ± 192.7	1022.0 ± 165.2	1029.6 ± 186.6	1040.5 ± 186.6	1.448	0.22
LIR (m)	3487.1 ± 1082.8	3504.7 ± 1015.4	3572.2 ± 973.3	3512.8 ± 1056.4	3499.3 ± 1029.7	0.353	0.84
HIR (m)	763.7 ± 455.0	808.9 ± 500.4	781.9 ± 453.5	818.1 ± 502.5	842.7 ± 513.5	1.063	0.37
SPT (m)	17.9 ± 37.7	17.8 ± 34.2	25.5 ± 42.0	19.2 ± 35.4	21.1 ± 37.4	2.391	0.05
ACC (n)	41.9 ± 17.0	42.4 ± 18.6	45.0 ± 18.6	42.9 ± 17.6	44.0 ± 18.3	1.552	0.19
DEC (n)	43.6 ± 18.3	44.1 ± 20.1	44.7 ± 19.6	43.6 ± 18.6	45.0 ± 20.3	0.289	0.89
TD (km)	5.42 ± 1.35	5.33 ± 1.43	5.38 ± 1.49	5.60 ± 1.44	5.08 ± 1.27	4.502	< 0.01
TS (km/h)	23.6 ± 2.7	23.0 ± 2.7	21.9 ± 2.5	23.5 ± 2.6	22.7 ± 2.4	22.245	< 0.01

LIR – low-intensity running, HIR – high-intensity running, SPT – sprinting, ACC – accelerations, DEC – decelerations, TD – total distance, TS – top speed

Table 3. Descriptive statistics and results of the comparison between players' positions regarding official matches

Variables	Wide defenders (n = 66) mean ± SD	Central defenders (n = 65) mean ± SD	Central midfielders (n = 98) mean ± SD	Wingers (n = 66) mean ± SD	Forwards (n = 67) mean ± SD	ANOVA	
						F	p
Walking (m)	897.6 ± 402.9	952.9 ± 363.4	727.3 ± 299.2	717.5 ± 332.7	792.0 ± 289.9	6.820	< 0.01
LIR (m)	4419.9 ± 1952.2	4733.8 ± 1894.6	4570.3 ± 2063.2	4100.2 ± 2182.2	4123.4 ± 1777.2	1.341	0.25
HIR (m)	1680.3 ± 793.1	1590.9 ± 843.5	1597.2 ± 741.7	1785.4 ± 1053.2	1440.7 ± 899.7	1.460	0.21
SPT (m)	75.2 ± 60.3	77.8 ± 64.9	24.0 ± 28.2	44.1 ± 55.4	32.9 ± 33.7	18.668	< 0.01
ACC (n)	44.3 ± 23.0	41.9 ± 23.9	34.8 ± 18.9	36.8 ± 18.3	28.9 ± 11.7	6.526	< 0.01
DEC (n)	57.2 ± 26.5	52.7 ± 24.3	46.4 ± 25.9	44.8 ± 24.1	37.7 ± 16.1	6.623	< 0.01
TD (km)	7.12 ± 3.07	7.37 ± 2.95	6.89 ± 2.99	6.68 ± 3.30	6.39 ± 2.65	1.048	0.38
TS (km/h)	25.3 ± 2.8	25.4 ± 2.5	23.4 ± 1.9	24.6 ± 3.9	25.3 ± 1.9	8.719	< 0.01

LIR – low-intensity running, HIR – high-intensity running, SPT – sprinting, ACC – accelerations, DEC – decelerations, TD – total distance, TS – top speed

fielders presented superior mean values both in accelerations (45.0 ± 18.6) and decelerations (44.7 ± 19.6) over the other field positions.

Table 3 resumes the descriptive statistics and the results of the comparison between field positions regarding official matches. A total of 362 observations were considered over 26 official matches. The results indicate substantial statistical differences between groups for walking ($F = 6.820, p < 0.01$, moderate effect size), sprinting ($F = 18.668, p < 0.01$, large effect

size), accelerations ($F = 6.526, p < 0.01$, medium effect size), decelerations ($F = 6.623, p < 0.01$, medium effect size), and top speed ($F = 8.719, p < 0.01$, moderate effect size). The central defenders displayed the highest distance covered in the walking (952.9 ± 363.4 m) and sprinting actions (77.8 ± 64.9 m). On the other hand, the wide defenders showed significantly higher mean values in the acceleration (44.3 ± 23.0) and deceleration (57.2 ± 26.5) actions. The central midfielders showed lower top speed values (23.4 ± 1.9 km/h)

than the other field positions. Although not significant, total distance was greater among the wide and central defenders (7.12 ± 3.07 km and 7.37 ± 2.95 , respectively).

Discussion

This study assessed the locomotor activities of female football players during training sessions and official matches according to their field position. In the training sessions, the central midfielders showed greater sprinting distances and lower top speed values, while the wingers covered higher total distances than their peers. During the official matches, the differences in the players' locomotor activities were more evident among the field positions. The central defenders covered more distance walking and sprinting, while the wide defenders presented the highest acceleration and deceleration actions.

The analysis of the training units suggests different results from those previously reported in the literature. In the current study, the wingers covered a significantly greater total distance, and the central midfielders presented a significantly superior sprinting distance compared to the players in the other field positions. However, in a past investigation among 18 female players competing in the First Spanish Division, the authors reported that during training sessions, the external load variables (accelerations, deceleration, and relative distance) were similar between playing positions [13], which is consistent with previous reports in male footballers [18]. Since players' locomotor activities are deeply related to training prescription, they should expect variations in results based on the coaching staff options, competitive level, and competition calendar. Even though it should be noted that research on locomotor activities during training units according to field position is still scarce in female football, it underlines the importance of the results of this study. This type of information is believed to help coaches individualise the training process, considering the specific demands required by each playing position on the field.

Within official matches, the current investigation indicates differences in the players' locomotor activities according to field position, which is consistent with previous research [7, 19]. In research conducted among 12 elite female football players aged 24.3 ± 4.2 years, the authors reported that the distances covered, high-intensity running, and sprint profiles varied according to the field position. The central defenders covered the least total distance (9.2 ± 0.6 km), high-intensity running ($1,777 \pm 439$ m), and sprinting distance

(417 ± 116 m) compared to their peers [7]. Previous total distance analyses concluded that the midfielders presented the highest values among field positions [7, 19, 20]. In this study, the highest total distance was covered by the central defenders (7.37 ± 2.95 km), which illustrates differences between match demands that could be related to the tactical system used and the players' competitive level. It is worth mentioning that the team's tactical system and the individual tactical roles of the players are linked to different physical demands. For instance, an investigation into male professional football reported an overall greater running performance of players in a system with 3 defensive players compared to 4 defensive players [21]. On the other hand, the competitive level might also help to interpret the lower values of total distance observed compared to those previously reported in female football [7, 19, 20]. A recent systematic review reported mean values of total distance ranging between 5.5 to 10.6 km for professional players and 3.9 to 8.5 km for amateur players [1]. Since the participants in this study were semi-professional players, considering previous research, a lower match intensity would be expected compared to top-level reports.

Although the total distance covered represents a basic indicator of the match demands, football includes the performance of high-intensity actions [22]. Thus, considering accelerations, decelerations, and sprinting indicators produces a more robust match performance analysis [5]. The ability to accelerate is crucial for players' successful response to match events, while the capacity to decelerate can be related to the change in direction performance [23]. In this study, the defensive players (wide and central defenders) significantly outperformed their peers in accelerations, decelerations, and sprinting distance. Indeed, in previous reports of male football, wide players (defenders and midfielders) attained higher accelerations and decelerations than their peers [24, 25]. In the female context, a review of internal and external intensity monitoring described that the central midfielders and forwards displayed the most decelerations while the central defenders displayed the most accelerations [1]. On the other hand, greater sprinting distances have been observed in wide midfielders and forwards [20], and central defenders and wingers [8]. Overall, regarding high-intensity actions (accelerations, decelerations, and sprinting), results among female football players are still quite diverse. Different thresholds and methodological approaches have been adopted across studies, which could influence the results reported. Thus, future research designed to investigate high-intensity

actions according to field position is still of great interest to understanding female football players' profiles.

Meanwhile, the overall analysis between training and match performance suggests enhanced differences in players' locomotor activities according to field position within the competition. Among the variables assessed, only low-intensity running, high-intensity running, and total distance did not show substantial variation among playing positions during official matches. These results are in line with previous literature on the topic. In elite female football, the authors of one study concluded that the analysis of positional differences during training sessions did not reflect the observed positional differences during the competition, particularly in total distance, accelerations, and decelerations [13].

The current study presents some limitations that should be recognised. The training session analysis did not consider the training plan prescription or the weekly variation caused by the match days. Indeed, including specific contents of the training prescription and the weekly strategies adopted regarding the training load would provide a better understanding of the results. Besides this, all players were included in the match analysis independently of their playing time, which could underestimate the results reported. On the other hand, other factors of variability between matches, such as the outcome, location, variation in score, and tactical formation [26, 27], which were not controlled in the present study, have been shown to influence players' performance.

Despite this, the current study provides important insights and practical implications for practitioners and coaching staff. Data on players' locomotor activities based on field position might increase the understanding of players' profiles, which could guide clubs and coaching staff in the player recruitment process and support them in designing tailored training programs according to match demands. Furthermore, quantifying players' locomotor activities with objective measures of training and competition supports a better organisation of the training plan and training volume [28]. This knowledge is crucial to optimise performance, provide adequate recovery periods, and reduce the risk of injury. Finally, it is of note that research in female football is still growing. Therefore, future research is still needed to address a more detailed analysis of players' locomotor activities by including the training plan contents and tactical formations adopted within the competition. The current study provides data regarding female footballers' locomotor activities during training units and official matches. In training

sessions, the central midfielders showed greater sprinting distance and lower top speed values, while the wingers covered a higher total distance than their peers. During official matches, the differences in players' locomotor activities were more evident among field positions. The central defenders covered more distance in walking and sprinting, while the wide defenders presented the highest acceleration and deceleration actions. Understanding the players' locomotor activities based on the field position makes it possible to identify individual profiles, which might support the players' recruitment process and the design of tailored training strategies according to the performance demands. Moreover, this study summarises indicators that might support coaching staff in the prescription of training plans and volume in female football. This knowledge is crucial to optimise performance, provide adequate recovery periods, and diminish the risk of injury.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Scientific Committee of the Faculty of Physical Education and Sport at the University of Madeira (ACTA N.113, 25 April 2021).

Informed consent

Participation was voluntary. Informed consent has been obtained from all individuals included in this study.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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