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# Variations of distance and accelerometry-based GPS measures and their influence on body composition in professional women soccer players

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**Abstract**

External intensity quantification and body composition assessments across the season allow soccer coaches to adjust the intensity during training sessions, thereby avoiding excessive fatigue and helping players maximize their physical fitness status during matches. Thus, the aims of this study were (1) to describe variations in external intensity periods of distance and accelerometry-based measures across the early and mid-competitive phases and (2) to analyze whether the intensity variations influenced body composition across the 2019/20 competitive season. Ten players from a Portuguese BPI Ligue team (professional league) participated in this study. The participants completed $\geqslant$80% of 57 training sessions and 13 matches. The athletes were assessed in three phases (before the start of the season, after 2 months, and after 4 months) for the following variables: body fat mass, soft lean mass, fat-free mass, intracellular water, extracellular water, total body water, and phase angle (50 kHz) through bioelectrical impedance analysis (InBody S10). A 10-Hz GPS device (PlayerTek) was used to collect distance and accelerometry-based measures, which included total distance, high-speed running distance, sprint distance, acceleration, deceleration, and player load. Repeated-measures analysis of covariance (ANCOVA) with GPS-derived measures as covariates or repeated-measures analysis of variance (ANOVA) was used to compare the three moments of assessment. Although the patterns of variables' responses were not the same as the season progressed, the values of body fat mass, fat-free mass, intracellular water, extracellular water, total body water, ratios of ECW/TBW, ECW/ICW, and phase angle improved. Variations in external intensity measures seem to influence the body composition variables across the season. These results may indicate good adaptations to the training and conditioning strategies managed by the coach and technical staff.

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## Introduction

In a recent editorial by Nassi et al.[1] a group of experts listed a set of challenges that women's soccer may face, which practitioners, scientists, and coaches can consider to more effectively manage the physiological and psychological demands of training and match play. One of the aforementioned challenges emphasizes the need for more research regarding intensity monitoring of physical and physiological demands in women's soccer.[2] Given that the scientific body of knowledge is mostly based on men's data, training and conditioning strategies should be reconsidered based on how soccer games stress women's metabolic systems specifically.[1] Thus, monitoring training data, anthropometry, body composition, and/or physical fitness daily throughout the season is key for ensuring the structured development of performance and preventing injury.[3]

Male and female soccer games can be characterized by intermittent efforts to perform activities of low-to-moderate intensities interspersed between high-intensity efforts.[4] Since soccer is an intermittent running-based sport that depends on the individual sport dynamic and interactions with contextual factors, the locomotor demands imposed on players vary throughout a match.[5,6] However, players spend a large part of a match jogging and running, while high-intensity sprinting is a small but determinant part of the game.[7] These high-intensity demands are associated with critical moments of the match (e.g. counterattacks, shooting opportunities).[8] Furthermore, although the distance covered in the games has remained the same for decades, clear evidence shows that matches have become more intense based on the progressive distance increase in high-intensity running (~30% in recent years) and sprinting (almost 70% in some cases).[9]

Considering the need to prepare female players for the locomotor and mechanical demands of matches, coaches have used intensity monitoring as part of the strategy to control the consequences of the training process on the players.[10] Intensity monitoring can be organized into two categories: external and internal.[11] External intensity is represented by the physical demands imposed by the training drills, while internal intensity refers to the psychophysiological responses that occur based on the physical demands.[12] Considering consistent and progressive training stimuli and their impact on internal and external intensity, adaptations in both biological dimensions and physical fitness are expected.[12]

Naturally, adaptations in female players are not exclusively related to training itself. Factors such as each player's lifestyle,[13] genetics,[14] and trainability[15] can influence their adaptations in response to training. However, players expect that the progressive training periodization will lead to positive physical and psychological adaptations and promote long-term health. Body composition is among the adaptations that can be potentially explained by the training process.[16] Body composition depends heavily on several factors. However, the training intensity and the volume imposed on an athlete can be associated with changes that take place over time.[17] In fact, periods of exposure to high-intensity demands (above 90% of maximum heart rate) can produce metabolic responses and changes that can ultimately alter how much fat mass and lean mass an athlete gains or losses.[17]

These concerns regarding body composition are related to its importance in explaining variations in some physical capacities.[18] For example, a high fat mass and dehydration can lower an athlete's aerobic capacity or repeated sprint ability, while a high lean mass promotes express strength and power.[19] Thus, it is important to control body composition variations and possibly identify factors that can explain the changes that occur during a season.

While it is important to recognize fat-free mass (FFM), there is no standard ideal value for this marker.[20] For example, values of around 16% can be expected in women soccer players, but the relationship between fat mass and performance is not straightforward. Moreover, the exact causes for variations of fat mass as they relate to the training process are still unknown. A recent study on female soccer players tested whether changes in body composition can be explained by the internal training intensity.[21] A significant influence of internal training intensity on the changes occurring in body composition was not found.[21] Therefore, more research is needed to analyze the association between training intensity and body composition in elite adult women soccer players throughout a season.

Thus, the aims of this study were twofold: (1) to describe the variations in external intensity periods of distance and accelerometry-based measures across the early and mid-competitive phases and (2) to analyze if intensity variations influenced athletes' body composition during the 2019/20 season.

## Materials and methods

### Experimental approach to the problem

This was an analytical and observational cohort study. The training sessions were performed during a 5-month period, from September 2019 to January 2020 (early-to-mid-season). The COVID-19 pandemic disrupted training sessions and matches as the season was suspended in March. The anthropometric and body composition assessments were conducted on three different occasions: in the first week of September (before the start of the season, A1), after 2 months (during the second week of November, A2), and 2 months after A2 (in the third week of January, A3). All assessments were made in the same room and under the same environmental conditions – namely, place, time of day, order of test application, temperature (22°C–24°C), and relative humidity (55%–65%) – by the same examiner. The players did not perform any complimentary training sessions during the study period.

### Participants

Ten elite women soccer players with a professional experience of 4.9 ± 2.1 years, an age of 24.6 ± 2.3 years, a height of 165 ± 6.0 cm, a body mass of 58.5 ± 9.3 kg, and a body mass index of 22.3 ± 3.8 kg/m$^2$, participated in this study.

We estimated the power of the sample size using a post hoc *F*-test: the within-group factor in a repeated-measures ANOVA. The analysis featured 97.5% of the actual power, with a total of 10 participants, a *p*-value of $< 0.05$, and an effect size (ES) of 0.6. We estimated the power of the sample size using a post hoc *F*-test: the within-group factor in a repeated-measures MANOVA. The analysis featured 99.8% of the actual power, with a total of 10 participants, a *p*-value of $< 0.05$, and an ES of 1.2. In addition, the power of the sample size was calculated for a matched-pairs *t*-test, with a total of 10 participants, a *p*-value of $< 0.05$, and an ES of 1.2. All calculations were made using G-Power.[22]

The players belonged to a team that participated in the Portuguese BPI League (a professional league) during the 2019/20 in-season. The inclusion criteria were regular participation in most of the training sessions (80% of the weekly training sessions) and playtime of at least half of the matches in the first half of the season.[23,24] The exclusion criteria were injury, illness, sickness, and/or non-performance in any of the assessments. The participants comprised three defenders, four midfielders, and three strikers.

All the participants were familiarized with the training protocols and had the study design carefully explained to them. Written informed consent from participants and approval from the Research Ethics Committee of the Polytechnic Institute of Santarém, Santarém, Portugal (252020 Desporto) were obtained prior to the investigation. Furthermore, the study was conducted according to the requirements of the Declaration of Helsinki. All the subjects received their club's medical approval to participate in the study and were instructed not to take any medication during the study.

**Table 1.** Participation in the 13 matches (min).

| Match number | Median | Minimum | Maximum |
|---|---|---|---|
| 1 | 93 | 0 | 93 |
| 2 | 93 | 0 | 93 |
| 3 | 93 | 26 | 93 |
| 4 | 104 | 23 | 104 |
| 5 | 102 | 49 | 102 |
| 6 | 95 | 45 | 95 |
| 7 | 103 | 94 | 103 |
| 8 | 99 | 48 | 99 |
| 9 | 96 | 96 | 96 |
| 10 | 95 | 1 | 95 |
| 11 | 98 | 98 | 98 |
| 12 | 98 | 23 | 98 |
| 13 | 100 | 58 | 100 |

During the first week of the assessment (A1) and during the last week of the assessment (A3), a food frequency questionnaire was administered to assess nutritional intake was applied over a 7-day period using a 24 h diet record. This was done for the players to verify their habits and food regimen routines.

The participants received instructions regarding the portion sizes, supplements, food preparation aspects, and other aspects pertaining to the accurate recording of their energy intake. The records were reviewed for macronutrient composition and total energy intake.[25] All the participants were asked to maintain their normal diet throughout the study period.

### Procedures

Data were collected in weeks with only one match, meaning that the team typically trained 3 days a week. During the study period, a total of 57 training sessions and 13 matches (with a minimum of 56% of total match time) occurred. The 57 training sessions were divided into 19 speed endurance sessions (e.g. long sprints, repeated sprints), 19 aerobic high-intensity sessions (e.g. interval training, medium- to large-sized games), and 19 ball-possession games and team/opponent tactics sessions.

The number of minutes played during each match is presented in Table 1. Between the first and second assessments, 30 training sessions and 6 matches occurred; between the second and third assessments, 27 training sessions and 7 matches occurred.

A portable 10 Hz GPS device (PlayerTek, Catapult Innovations, Melbourne, Australia) was used to produce specific information regarding training and match

**Table 2.** Comparisons of running distance and accelerometry-based measures between periods.

| Variable | A1–A2 | A2–A3 | $p$ | ES | Change % |
|---|---|---|---|---|---|
| Training duration (min) | 2162.46 ± 273.24 (1966.99–2357.92) | 2136.17 ± 385.55 (1860.36–2411.96) | 0.865 | – | −1.2 |
| Total distance (m) | 118895.75 ± 15015.10 (108,154.6–129,636.9) | 137740.74 ± 29030.76 (116,973.4–158,508.1) | 0.122 | – | 13.7 |
| High-speed running (m) | 101230.0 ± 44003.0 (69,752.0–132,708.0) | 97880.0 ± 42128.4 (67,743.0–128,017.0) | 0.803 | – | −3.4 |
| Acceleration (nr) | 5408.69 ± 787.61 (4845.27–5972.11) | 6789.64 ± 1601.51 (5643.98–7935.29) | 0.033 | −1.09 (−1.71, −0.47) | 20.3 |
| Deceleration (nr) | 4514.89 ± 539.17 (4128.88–4900.29) | 6463.27 ± 1560.82 (5346.73–7579.82) | 0.006 | −1.60 (−2.60, −0.59) | 30.1 |
| Player load (AU) | 5939.00 ± 503.10 (5579.10–6298.90) | 5512.99 ± 1174.66 (4672.69–6353.29) | 0.345 | – | −7.7 |

min: minutes; m: meters; nr: number; AU: arbitrary units; A: assessment; ES: effect size.

intensity. This device also incorporated a tri-axial 100-Hz accelerometer. These types of GPS devices seem to be the most valid and reliable for use in team sports.[26]

## Anthropometric and body composition assessment

The anthropometric and body composition measures were obtained with the subjects dressed in light clothing without shoes. The participants were further asked to remove all objects that could interfere with the bioelectrical impedance assessment. The participants' weights and heights were measured using a stadiometer with an incorporated scale (Seca 220, Hamburg, Germany) according to standardized procedures.[27]

The body composition data were obtained with bioelectrical impedance analysis through Inbody S10 (model JMW140, Biospace Co, Ltd., Seoul, Korea) according to the manufacturer's guidelines[28,29] and the recommendations of previous studies.[21,30] Eight electrodes were placed on eight tactile points (both thumbs, middle fingers, and ankles) for the multi-segmental frequency analysis. Next, a total of 30 impedance measurements were obtained at frequencies of 1, 5, 50, 250, 500, and 1000 kHz from different segments of the body, such as the right and left arms, trunk, and right and left legs. Moreover, three different frequencies (5, 50, and 250 kHz) were used to collect the 15 reactance, PhA measurements from the right and left arms, trunk, and right and left legs, respectively. The variables collected were body fat mass (BFM), soft lean mass (SLM), FFM, intracellular water (ICW), extracellular water (ECW), total body water (TBW), phase angle (PhA, 50 kHz), ECW/TBW ratio, and ECW/ICW.

The measurements were carried out in the morning[21] in a room with an ambient temperature and relative humidity of 22°C–23°C and 50%–60%, respectively, after a minimum of 8 h of fasting and after players' bladders were emptied. The participants adopted a supine position with their arms and legs abducted at a 45° angle, and the dorsal surfaces of their right hand and foot were cleaned with alcohol. After participants rested for 10 min in a quiet room, eight electrodes were placed on the cleaned surfaces, and the measurements were taken. The subjects did not exercise or ingest caffeine or alcohol during the 12 h prior to the assessment. Furthermore, they were assessed only if they were in the luteal phase of the ovulatory menstrual cycle. Otherwise, they waited until they were in the luteal phase. All the assessments were performed by the same evaluator to minimize possible measurement errors.[31]

## Training and match intensity quantification

About 10 min before each training session and match, PlayerTek devices were turned on, and the players were asked to use them. The devices were turned on and placed in a specifically customized vest pocket located on the posterior side of the upper torso fitted tightly to the body, as is typically done in matches. The devices were placed and checked by the same coach of the team, and each player always used the same device.[32]

The measures used for analysis were total distance, high-speed running distance ($\geqslant 15$ km/h),[33] numbers of accelerations ($> 1$ m/s) and decelerations ($< 1$ m/s), and player load. All variables were analyzed based on the accumulated values for each assessment period.

## Statistical procedures

Descriptive statistics (mean ± standard deviation and 95% confidence interval) were calculated for all the measurements. All the variables were checked for normality and homoscedasticity using the Shapiro-Wilk and Levene tests, respectively. Then, Pearson's product-moment correlation coefficient between body composition variables and intensity quantification measures was calculated; the following thresholds were considered: $\leqslant 0.1$, trivial; $> 0.1$–0.3, small; $> 0.3$–0.5, moderate; $> 0.5$–0.7, large; $> 0.7$–0.9, very large; $> 0.9$–1.0, almost perfect.

If correlations were detected, an analysis of covariance (ANCOVA) with repeated measures was performed for the variables that obtained a normal distribution. This way, the three body composition

**Table 3.** Correlation analysis between measures for A1–A2.

| Measures | Min | TD | HSR | ACC | DEC | PL |
|---|---|---|---|---|---|---|
| Body weight | −0.080 | −0.518 | −0.624 | −0.401 | −0.427 | −0.429 |
| Body fat mass | −0.481 | −0.519 | **−0.693** | −0.540 | −0.502 | −0.528 |
| Soft lean mass | 0.199 | −0.376 | −0.410 | −0.204 | −0.262 | −0.248 |
| Fat-free mass | 0.188 | −0.377 | −0.412 | −0.207 | −0.265 | −0.252 |
| Intracellular water | 0.223 | −0.356 | −0.384 | −0.184 | −0.241 | −0.227 |
| Extracellular water | 0.154 | −0.406 | −0.460 | −0.248 | −0.311 | −0.295 |
| Total body water | 0.198 | −0.376 | −0.413 | −0.208 | −0.268 | −0.253 |
| ECW/TBW | −0.383 | −0.148 | −0.242 | −0.225 | −0.243 | −0.245 |
| ECW/ICW | −0.471 | −0.268 | −0.362 | −0.400 | −0.370 | −0.381 |
| TBW/fat-free mass | 0.226 | −0.050 | −0.074 | −0.081 | −0.111 | −0.034 |
| Phase angle (θ, 50 kHz) | 0.357 | 0.204 | 0.217 | 0.464 | 0.509 | 0.509 |

ECW: extracellular water; TBW: total body water; ICW: intracellular water; Min: accumulated training and match duration; TD: total distance; HSR: high-speed running; ACC: acceleration; DEC: deceleration; PL: player load
Correlations are highlighted in bold ($p = 0.026$).

**Table 4.** Correlation analysis between measures for A2–A3.

| Measures | Min | TD | HSR | ACC | DEC | PL |
|---|---|---|---|---|---|---|
| Body weight | 0.031 | −0.066 | −0.455 | −0.094 | −0.092 | 0.086 |
| Body fat mass | −0.402 | −0.485 | −0.395 | −0.285 | −0.255 | 0.246 |
| Soft lean mass | 0.200 | 0.127 | −0.345 | 0.017 | 0.007 | 0.000 |
| Fat-free mass | 0.197 | 0.123 | −0.346 | 0.010 | 0.001 | −0.005 |
| Intracellular water | 0.198 | 0.127 | −0.343 | 0.019 | 0.009 | 0.004 |
| Extracellular water | 0.209 | 0.131 | −0.394 | −0.229 | −0.341 | −0.303 |
| Total body water | 0.202 | 0.128 | −0.345 | 0.016 | 0.007 | −0.001 |
| ECW/TBW | −0.059 | −0.058 | 0.210 | −0.055 | −0.047 | −0.095 |
| ECW/ICW | −0.060 | −0.010 | 0.337 | −0.067 | −0.061 | −0.186 |
| TBW/fat-free mass | −0.055 | −0.005 | −0.037 | 0.145 | 0.132 | 0.096 |
| Phase angle (θ, 50 kHz) | 0.024 | −0.149 | −0.431 | −0.260 | −0.269 | −0.130 |

ECW: extracellular water; TBW: total body water; ICW: intracellular water; Min: accumulated training and match duration; TD: total distance; HSR: high-speed running; ACC: acceleration; DEC: deceleration; PL: player load.

assessments could be compared, with intensity measures used as covariates. If no correlation was detected, a repeated-measures ANOVA was calculated to compare the three assessments. A *t*-test was also applied to compare measures of intensity quantification for both periods. The change percentage was also calculated for comparative analysis.

A *p*-value of $\leqslant 0.05$ was established as significant, and all the data were analyzed using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA) for Windows. Furthermore, the change (%) was calculated between each comparison. Finally, the Hedges ES was computed to determine the effect magnitude by dividing the difference between two means by the standard deviation from the data. The following criteria were used: $< 0.2$ = trivial, 0.2–0.6 = small effect, 0.6–1.2 = moderate effect, 1.2–2.0 = large effect, and $> 2.0$ = very large.[34]

## Results

Table 2 summarizes the comparisons of the accumulated GPS data for the periods of analysis. Only accelerations and decelerations presented significant differences. Specifically, higher values were recorded for A2–A3 than for A1–A2.

Table 3 shows the correlation analysis between body composition and intensity variables during A1 and A2. Table 4 shows the correlation analysis between body composition and intensity variables between A2 and A3. The only significant correlation was found between BFM and HSR during A1–A2 ($p = 0.026$).

Table 5 shows between-period comparisons of body composition variables. Since only BFM and high-speed running denoted a large correlation between A1 and A2, high-speed running was used as a covariate to compare the three periods. A linear interaction between this variable and BFM was verified ($p = 0.043$; ES = −1.34 (0.37, −2.06)).

The remaining comparisons were performed through a repeated-measures ANOVA. Significant differences were detected between A1 and A2, with moderate to very large effects. Namely, these were as follows: BFM ($p = 0.029$; ES = 2.09 (0.99, 3.19)), SLM ($p = 0.016$; ES = −1.09 (−1.81, −0.38)), FFM ($p = 0.011$; ES = −1.22 (−1.93, −0.50)), ICW ($p = 0.010$;

**Table 5.** Comparisons of body composition variables between assessments.

| Variables | A1 | A2 | A3 | Change % (A1–A2) | Change % (A2–A3) | Change % (A1–A3) |
|---|---|---|---|---|---|---|
| Body weight (kg) | 58.50 ± 2.93 (51.86–65.14) | 58.00 ± 2.44 (52.48–63.52) | 58.40 ± 2.47 (52.81–63.99) | −0.9 | 0.7 | −0.2 |
| Body fat mass (kg) | 12.07 ± 1.31 (8.98–15.16)[a] | 9.61 ± 0.91 (7.46–11.76) | 9.71 ± 0.90 (7.59–11.83) | −25.6 | 1.0 | −24.3 |
| Soft lean mass (kg) | 43.66 ± 1.45 (40.37–46.95)[a] | 45.32 ± 1.70 (41.46–49.18) | 45.67 ± 2.09 (40.94–50.40) | 3.7 | 0.8 | 4.4 |
| Fat-free mass (kg) | 46.43 ± 1.54 (42.95–49.91)[a,b] | 48.39 ± 1.82 (44.28–52.50) | 48.69 ± 2.22 (43.67–53.71) | 4.1 | 0.6 | 4.6 |
| Intracellular water (L) | 21.17 ± 0.71 (19.57–22.77)[a] | 22.09 ± 0.84 (20.19–23.99) | 22.28 ± 1.05 (19.91–24.65) | 4.2 | 0.9 | 5.0 |
| Extracellular water (L) | 12.76 ± 0.43 (11.79–13.73)[a] | 13.12 ± 0.48 (12.03–14.21) | 13.17 ± 0.56 (11.89–14.45) | 2.7 | 0.4 | 3.1 |
| Total body water (L) | 33.93 ± 1.13 (31.37–36.49)[a] | 35.21 ± 1.32 (32.23–38.19) | 35.45 ± 1.61 (31.81–39.09) | 3.6 | 0.7 | 4.3 |
| ECW/TBW | 0.376 ± 0.001 (0.37–0.38)[a,b] | 0.373 ± 0.002 (0.37–0.38) | 0.372 ± 0.001 (0.37–0.38) | −0.8 | −0.3 | −1.1 |
| ECW/ICW | 0.602 ± 0.004 (0.59–0.61) | 0.595 ± 0.004 (0.59–0.61) | 0.592 ± 0.004 (0.58–0.60) | −1.2 | −0.5 | −1.7 |
| TBW/fat-free mass | 73.12 ± 0.05 (72.98–73.22)[a,b] | 72.74 ± 0.07 (72.58–72.90) | 72.82 ± 0.6 (72.69–72.95) | −0.5 | 0.1 | −0.4 |
| Phase angle (θ, 50 kHz) | 6.27 ± 0.11 (6.02–6.52)[b] | 6.54 ± 0.14 (6.22–6.86) | 6.98 ± 0.10 (6.74–7.22) | 4.1 | 6.3 | 10.2 |

A1: assessment 1; A2: assessment 2; A3: assessment 3; ECW: extracellular water; ICW: intracellular water; TBW: total body water.
[a]Denotes significant difference between A1 and A2 ($p < 0.05$).
[b]Denotes significant difference between A1 and A3 ($p < 0.05$).

ES = −1.19 (−2.00, −0.39)), TBW ($p = 0.015$; ES = −1.07 (−1.81, −0.34)), ECW/TBW ($p = 0.019$; ES = 1.32 (−2.00, 4.63)), and TBW/FFM ($p = 0.001$; ES = 7.16 (5.88, 8.43)). The only small effect was found for ECW ($p = 0.049$; ES = −0.77 (−1.62, 0.08)).

Finally, between A1 and A3, significant differences with large to very large effects were recorded for FFM ($p < 0.001$; ES = −1.34 (0.37, −2.06)), ECW/TBW ($p = 0.050$; ES = 3.61 (−0.01, 7.23)), TBW/FFM ($p < 0.001$; ES = 1.44 (0.75, 2.14)), and PhA ($p = 0.007$; ES = −6.45 (−8.82, −4.07)).

## Discussion

The aim of this study was twofold: (1) to describe the variations in external intensity periods of distance and accelerometry-based measures across the early and mid-competitive phases of a soccer season and (2) to analyze if the intensity variations influenced players' body composition across the 2019/20 season. Our principal evidence revealed (1) that the numbers of accelerations ($p = 0.033$; ES = −1.09 (−1.71, −0.47)) and decelerations ($p = 0.006$; ES = −1.60 (−2.60, −0.59)) were significantly greater in A2–A3 when compared to A1–A2 and (2) that several body composition measures exhibited significant changes across the 2019/2020 season, particularly between A1 and A2. Additionally, high-speed running and BFM were correlated in A1–A2 ($r = -0.693$; $p = 0.026$). The associations between the training duration, total distance, and relative changes in anthropometry and body composition were unsystematic.

Significant between-period differences were recorded in the numbers of accelerations and decelerations. Intense accelerations and decelerations are a substantial part of high external intensity, as they impose a specific physiological and mechanical strain on players.[9,35] The quantification of these specific fundamental actions is extremely important because they can describe the rate of variation of the speed in relation to time.[36] As such, when this variable is not quantified, the levels of stress and accumulated load may be underestimated.[35]

It has been reported that when these metrics are considered, the training intensity increases by 6%–8%.[37] According to the present study's results, the A2–A3 period involved more high-intensity actions (i.e. power actions) than the A1–A2 period. However, the number of minutes spent training was very similar between periods. Furthermore, the average accumulated player load value was higher in the A1–A2 period than in the A2–A3 period. Thereafter, the differences between periods could be associated with goals of the season and the current position in the classification table. An individual's capacity to perform more high-intensity actions later in the season is fundamental, particularly if the team is trying to achieve the top positions in the classification or intending to maintain its competition level.

The frequency of high-intensity accelerations and decelerations completed during matches has been associated with decreases in neuromuscular performance and indicators of muscle damage.[38–41] Such outcomes confirm the usefulness of these metrics for coaches and technical staff.

Accelerations and decelerations have also been associated with high ratings of perceived exertion and blood lactate concentration.[35,42] Recently, Douchet et al.[35] reported that a week with more accelerations and decelerations increased fatigue among 12 elite women soccer players, as indicated by the greater rating of perceived exertion and Hooper index scores. The results of the present study could be explained by the coach's preference to conduct training exercises with a larger relative field area per player[43] (e.g. 4 vs 4 players, plus goalkeepers, on a $30 \times 40$ m field)[35] in the A2–A3 period. Such exercises tend to increase the number of off-the-ball movements, increasing physiological demands.[44]

Table 4 showed significant differences between A1 and A2 for various body composition variables, namely BFM, SLM, FFM, ICW, ECW, TBW, ECW/TBW ratio, and TBW/FFM ratio. This high number of significant differences may be associated with a sudden increase in training intensity. Such a sharp increase is typical of the pre-competitive season[45] and is followed by further high training intensity during the beginning of the in-season.[23]

The results shown in Table 4, when considered together with those in Table 1, indicate that the coach and his technical staff properly managed the training intensity and progression/planning of the analyzed periods. Specifically, while the intensity applied in the training sessions in the first phase of the season induced chronic physiological adaptations, this was not the period with the highest intensity sessions (A2–A3 assessment). If intensity management is unbalanced, players may experience an increased risk of injury, decreased aerobic capacity, and decreased performance.[45]

The present study also showed a negative association between BFM levels and the accumulative values of high-speed running in A1–A2 ($r = -0.693$; $p = 0.026$). This result is in line with previous research that investigated the influence of BFM on athletes' performance.[46] The BFM values showed a sharp decrease between A1 and A2 and then remained constant between A2 and A3 (Table 4). This result confirmed the findings of our previous investigation of professional women soccer players.[21]

Regarding the remaining parameters of body composition, the values of TBW and ICW increased during the analyzed period, confirming previous results which indicate an increase in muscle mass. Simultaneously, studies have reported a relationship between muscle mass and the ability to produce strength and power.[21,47] The present results suggest that the coach and technical staff effectively managed intensity to maximize the athletes' capabilities, such as strength and power.[19,25] However, future studies should also assess such capabilities.

The phase-angle measure was significantly greater in A3 than in A1 ($p = 0.007$; ES $= -6.45$ ($-8.82$, $-4.07$)). According to Francisco et al.[48] this assessment is extremely useful for coaches, nutritionists, and exercise physiologists to provide specific recommendations to improve athletic performance and prevent performance declines. Our previous study[21] showed a mean value of $6.26° \pm 0.11°$ in A1, $6.67° \pm 0.31°$ in A2, and $6.99° \pm 0.10°$ in A3. These values align with the present study, which shows an average value of $6.27° \pm 0.11°$ in A1, $6.54° \pm 0.14°$ in A2, and $6.98° \pm 0.10°$ in A3. A reduced value in this parameter may indicate muscle injury due to cell membrane rupture.[49]

Scientific research on women soccer athletes is still scarce,[21] especially at the professional level. To the best of our knowledge, this is the first study on elite women soccer players to include several body composition variables and external intensity variables. Associations between individual match playing time and changes in body composition among elite women soccer players should be studied in the future.

Despite the relevance of our study, some limitations should be highlighted. First, a major limitation was the sample size and the inclusion of only one team. Second, the positions of each player were not considered due to the size of the sample, which may have influenced our results. For instance, a previous study conducted on women soccer players from the first Spanish division showed that central defenders and wide midfielders presented low high-speed running distances ($>15$ km/h) while strikers and central midfielders exhibited higher intensities in high-speed running distance and numbers of accelerations and decelerations during matches.[33] However, the same study did not present any significant between-position differences during training sessions due to the common utilization of small-sided games.[33] Third, high-speed running distance was defined as $>15$ km/h, but this speed that defines high intensity can be different between individuals, once it can overestimate, or underestimate the actual speed intensity.

Finally, as mentioned in a previous study, two other limitations should be pointed out. First, the use of tetra-polar and multi-frequency bioimpedance equipment, such as InBody S10, is not a reference method for body composition analysis. Second, the fact that nutritional intake was assessed by a questionnaire to control players' nutritional habits could have influenced the results. A week-by-week assessment may improve such an analysis; this matter should be addressed in future investigations.[21]

We recommend that the authors of future studies include a larger sample so that they can study situational variables, such as playing position, playing status (starter vs non-starter), and the number of matches per week, to better understand training intensity distribution. Furthermore, an analysis based on week-by-week measures could detect other variations that help to explain body composition changes across a season.

## Conclusion

Although the pattern of variables' responses changed as the season progressed, improvements were observed in body fat mass, fat-free mass, intracellular water, extracellular water, total body water, and phase angle. The data suggest that variations in external intensity measures influence body composition variables across the season. These results may indicate good adaptations to training and conditioning strategies.

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