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Comparisons of external load variables among periods, playing status, and positions in professional soccer team: A case study

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Abstract

The aims of this study were to compare weekly variations of training monotony (TM) and training strain (TS) among periods of the season, playing status and playing positions in professional soccer athletes. Nineteen male professional soccer players were monitored daily over a 43-week period for their total distance, sprint distance ($>23\,km\,h^{-1}$), acceleration (Acc, $>4\,m\,s^{-2}$), and decelerations numbers (Dec, $>-4\,m\,s^{-2}$). Players were divided in groups of 10 starters and 9 non-starters; and by three central defenders (CD), four wide defenders (WD), four central midfielders (CM), four wide midfielders (WM), and four strikers (ST). Season data was divided in pre-, early-, mid-, and end-season. There were significant differences for TM through sprint distance between playing positions in mid- and full-season. In mid-season, sprint distance was meaningfully greater for CD than WD ($p = 0.006$; $g = 1.74$ [0.06, 3.95]), CM ($p = 0.002$; $g = 2.04$ [0.28, 4.46]), WM ($p = 0.005$; $g = 1.78$ [0.09, 4.02]), and ST ($p = 0.002$; $g = 2.05$ [0.28, 4.46]). Regarding full-season, TM of sprint distance was significantly greater for CD than WD ($p = 0.031$; $g = 1.59$ [−0.04, 3.73]), CM ($p = 0.011$; $g = 1.83$ [0.13, 4.11]), and ST ($p = 0.023$; $g = 1.52$ [−0.10, 3.59]). The study revealed that TM and TS of sprint distance in mid-season was meaningfully greater for CD than for WD, CM, WM, and ST. No differences between starters and non-starters were found.[AQ: 4]

Keywords

Football, GPS, sprint, acceleration, deceleration, starters, non-starters, season periods, playing positions, Iran Pro League

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Introduction

One of the common practices in professional soccer is the quantification of training load via measures of volume and intensity.[1] Such quantification allows the optimization management of the training process over the in-season period.[2] In this sense, global positioning systems (GPS), multi-camera tracking systems or inertial sensor units can provide several objective measures such as total distance covered, sprint distance covered, acceleration, or decelerations.[3] Those measures allow the quantification of external load that is related to the exercise demands or exercise mechanical work.[4,5]

As mentioned in the previous lines, there are different external measures that can provide different information on stimulus applied during training and competition which allow the quantification of low, moderate, and high intensity zones.[1] For instance, the measure of total distance provides insufficient

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information about intensity. Total distance is a measure that describes volume of the session in terms of distance covered. In this sense other measures such sprint distances, accelerations, and/or decelerations, which are involved in the actions related to the decisive moments of a soccer match,[6–8] can determine the intensity of the training process.[1] However, these intense actions may provoke neuromuscular fatigue, and a present a higher risk of injury,[9,10] thus their monitorization is warranted.

The monitorization of load could be performed through the control of day-to-day and weekly variations over the season. Such control could be measured through the training monotony (TM) and strain (TS) indices. While TM is calculated to describe the load variability within the week (based on the division of daily mean load by the standard deviation), TS is calculated to describe TM multiplied by the accumulated load of the full week.[11]

Recently, TM and TS indices have been used through running distances[10,12,13] and acceleration/deceleration[14–16] to understand the variations of these indices based on playing statuses[14–16] and playing positions[14,17] over different periods of the season. Overall, higher values were found in pre- and early-season periods.[13,15,16] Considering players playing statuses, a general tendency of higher values for TM and TS were found for starters than non-starters,[15,16] while Oliveira et al. did not report such differences between starters and non-starters.[13] Regardless of playing positions, it was found that wide defenders and wide midfielders displayed higher TS of high-speed running distance and number of sprints during the season compared to the other positions.[12] Another study found higher values for central midfielders for TS of total distance when compared with strikers. The same study also found higher values for wide defenders for TM and TS of high-speed running when compared with central defenders in some mesocycles of the season, with no other differences being found.[17] In line with the previous research,[17] no differences were found for TM and TS of high-intensity accelerations or decelerations.[12]

Furthermore, none of the previous studies analyzed TM and TS calculated through sprint distance and accelerometry based variables simultaneously. Such analysis could provide more information considering the different type of exercises performed during the season (e.g. small-sided games, large-sided games, or official matches) which would contribute to a better understanding of the day-to-day and weekly variations over the season. Therefore, the aims of this study were (i) to verify the weekly variations of training monotony (TM) and training strain (TS) through total distance, sprint distance, accelerations (Acc, $> 4\,\mathrm{m\,s^{-2}}$), and decelerations (Dec, $< 4\,\mathrm{m\,s^{-2}}$)[18] and (ii) compare among different periods of a professional soccer season (pre, early, mid, and end-season), between player status (starters and non-starters) and among playing positions (central defenders (CD), wide defenders (WD), central midfielders (CM), wide midfielders (WM), and strikers (ST)).

Methods

Participants

Nineteen elite male soccer players who participated in the Iran Pro League took part in the present study. Participants were divided according to their playing status in two groups: starters ($n = 10$, age 28.5 ± 4.2 years, 1.83 ± 0.05 m, and 74.8 ± 3.6 kg) and non-starters ($n = 9$, age 26.4 ± 5.1 years, 1.7 ± 0.06 m, and 74.2 ± 4.1 kg). Additionally, participants were divided according to their playing positions: three CD, four WD, four CM, four WM, and four ST.

The inclusion criterion was based on participation $\geqslant 80\%$ of the weekly training sessions.[19] The exclusion criteria was based on a lack of player information, illness/injury for two consecutive weeks[12] or on being a goalkeeper – due to the different training and match demands related to this position.[19]

The criteria to define starters and non-starters was adapted from previous studies that considered starters as the players that accumulated $\geqslant 60\%$ of the total play time during official matches in the competitive season, while non-starters were the remaining players.[13,15,19,20]

In our study, we implemented specific training sessions on the day following Match Day 1 (MD + 1) and Match Day 2 (MD + 2). It is common for starters to undergo a reduction in training load during these sessions. For non-starters, these MD + 1 and MD + 2 training sessions were strategically designed to expose them to higher levels of high-speed running distance), sprinting distances, accelerations, and decelerations. The primary objective was to ensure that non-starters could sustain their fitness levels and competitive readiness despite not participating in the match on those specific match days. In contrast, starters engaged in recovery sessions on the respective days following matches.

The training sessions for non-starters comprised a variety of exercises meticulously tailored to achieve the targeted high-speed running distance and sprinting distances. These exercises encompassed activities such as pursuing opponents and drills focused on goal-scoring. As an illustration, players participated in drills where they were required to sprint to take a shot on goal and promptly transition to defending against the next player attempting to score in the opposing goal. This training approach enabled non-starters to accumulate the requisite high-speed running distance and sprinting distances during training sessions. Furthermore, our training program for non-starters incorporated small-sided games to attain prescribed acceleration and deceleration objectives. One notable exercise involved the utilization of two squares and three teams. The team that lost possession of the ball was immediately tasked with pressing to regain it, while the team that recovered the ball endeavoured to connect with the opposite square. These exercises facilitated non-starters in reaching their acceleration and deceleration targets and fostered a competitive training environment.

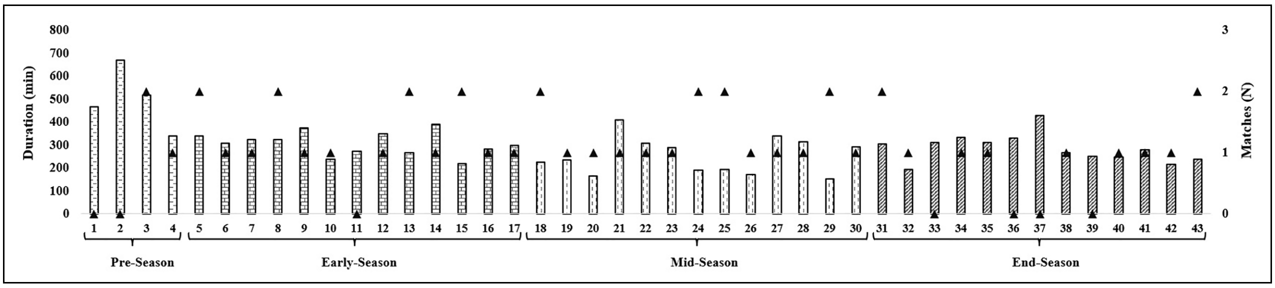

Figure 1. Total duration per each week of the 43 weeks of the season.
Min: minutes.

The present study was conducted according to the requirements of the Declaration of Helsinki and was approved by the University of Mohaghegh Ardabili research ethics committee.

Experimental design

The present study is a descriptive-longitudinal approach where the players were monitored for 43 consecutive weeks during the full season. The experimental design was adapted from a previous study[19] in which all training sessions ($n = 229$) conducted during the main team sessions were considered and data from rehabilitation or recuperation was excluded. The duration of the training sessions included the warm-up, main, and cool-down phases, plus stretching. All training sessions were planned by the coach and technical staff, and the researchers only standardized the first and final 30 min (i.e. before and after each training session) for daily data collection purposes (i.e. all training sessions and matches).

The study period included the beginning of the pre-season (June 17, 2019) and lasted until the end of the regular season (April 12, 2020). The season was organized into four periods: pre-season (Weeks 1–4); early-season (Weeks 5–17); mid-season (Weeks 18–30); and end-season (Weeks 30–43). It should be highlighted that the league matches were cancelled between the 34th and 35th Weeks of the Iran Pro League (Persian Gulf Pro League, is the top-tier professional soccer league in Iran) due to the outbreak of the COVID-19 pandemic.

The number of competitive matches and total training time in minutes per week of the full season are presented in Figure 1.

External load monitoring

Following the same procedures of a previous study,[19] during each session, players were monitored using a 15 Hz global positioning system (GPSPORTS systems Pty Ltd, Model: serial peripheral interface (SPI) High-Performance Unit (HPU); Canberra, Australia) which includes the following features: 15 Hz location GPS; acceleration: 100 Hz; Mag: 50 Hz, TriAxial; dimensions: the smallest device on the market (74 mm × 42 mm × 16 mm); robust SPI HPU based on mining / industrial strength electronic design; waterproof and data transfer; infrared; weight 56 g. This device showed a high validity and reliability.[21,22] All procedures regarding the use of this system were reported elsewhere.[19]

Based on previous research,[23–25] the following variables were used and analyzed for the present study: total distance, sprint distance ($>23\,km\,h^{-1}$), acceleration number (Acc, $>4\,m\,s^{-2}$), and decelerations number (Dec, $>-4\,m\,s^{-2}$). Total distance was used as a general measure of load quantification that includes all work performed by the athletes from low to high intensity.

Calculation of training indices

Through total distance, sprint distance, Acc, and Dec, the following variables were calculated: (i) TM (mean of training load during the seven days of the week divided by the standard deviation of the training load of the seven days);[15,16] and (ii) TS (sum of the training load for all training sessions during a week multiplied by training monotony).[15,16] All indices were presented in arbitrary units (AU).

For a better clarity of both TM and TS calculations, a higher TM value could mean that low standard deviations (SD) could be associated with minor variations during the week while a higher TS value could mean higher load with minor variations during the week.[26]

Statistical analysis

All variables were presented in the results section as mean ± SD. First, descriptive statistics were used to describe and characterize the sample. The Shapiro–Wilk (see Supplemental Material 1) and Levene tests (in which for TM_{Dec} and TS_{Dec} in early season and for TS $_{TD}$ for in end-season did not assume homogeneity) were used to test the assumption of normality and homoscedasticity, respectively, while Mauchly's test was used to analyze sphericity assumption. In this way, results from Mauchly's test indicated that the assumption of sphericity had been violated, thus, the Greenhouse-Geisser correction was applied.

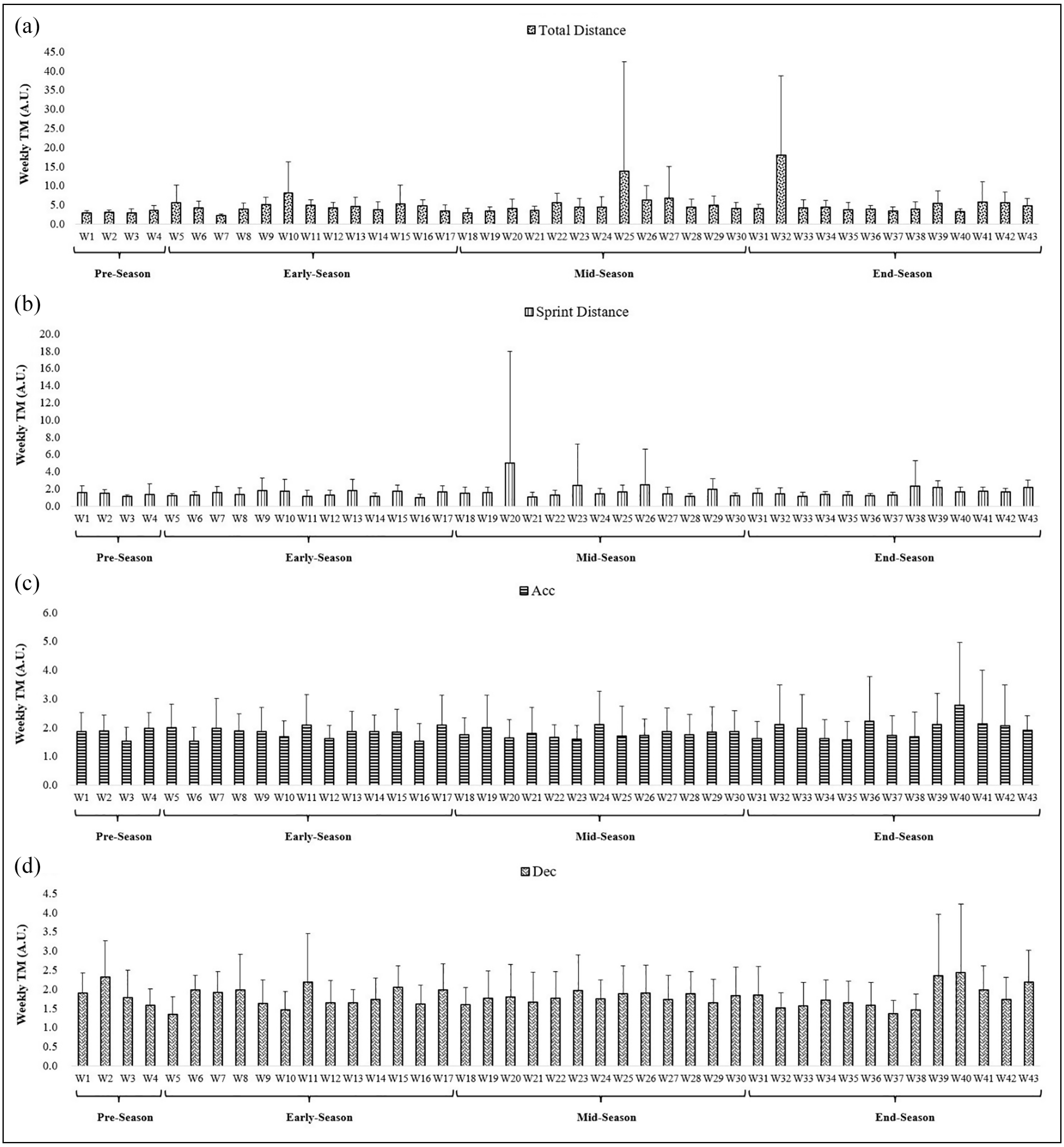

Figure 2. Weekly variations of training monotony (TM) through total distance (a), sprint distance (b), acceleration (Acc, c), and deceleration (Dec, d) across different periods of a professional soccer season.

A repeated measures ANOVA was used with the Bonferroni post hoc test once variables obtained normal distribution (Shapiro–Wilk $>$ 0.05), and the Wilcoxon and Mann–Whitney tests were used for variables that did not obtain normal distribution.

The effect sizes (ES) were expressed as partial eta-squared values within repeated measures ANOVA squared (η_p^2; small $\geqslant 0.01$, medium $\geqslant 0.06$, and large $\geqslant 0.14$), and Hedge's *g* was also calculated to determine the magnitude of pairwise comparisons. The following benchmarks were used: small *(d = 0.2)*, *medium (d = 0.5)*, and *large (d = 0.8)*.[27,28] All data were analyzed using IBM SPSS Statistics (version 22, IBM Corporation, SPSS Inc., Chicago, IL, USA).

Results

The Supplemental Material shows the normality results for all variables. Figures 2 and 3 show an overall view of the weekly average for TM and TS calculated through total distance (A), sprint distance (B), Acc (C), and Dec (D) across different periods of a professional

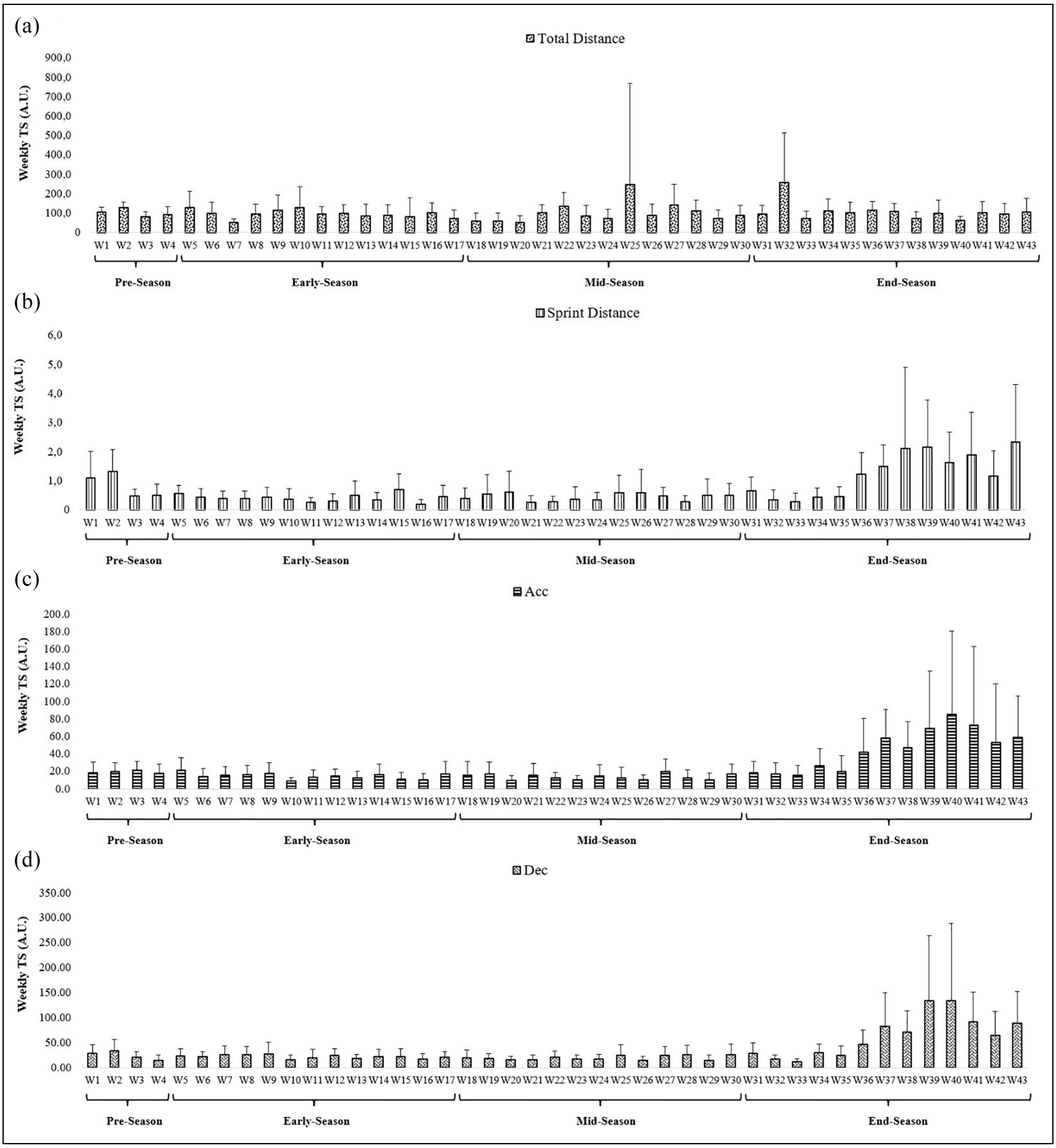

Figure 3. Weekly variations of training strain (TS) through total distance (a), sprint distance (b), acceleration (Acc, c), and deceleration (Dec, d) across different periods of a professional soccer season.

soccer season (pre-season, early-season, mid-season, and end-season).

Overall, Figure 2 shows that the highest TM through total distance occurred during Week 32 (18.0 Arbitrary Units (AU)), sprint distance occurred during Week 20 (5.1 AU), and Acc and Dec occurred during Week 40 (2.8 and 2.4 AU, respectively), while lowest value for TM was found during Week 7 (2.3 AU) through total distance, during Week 16 (1.01 AU) through sprint distance, during Week 3 (1.5 AU) through Acc, and during Week 5 (1.4 AU) through Dec.

Figure 3 presents that the highest TS through total distance occurred during Week 32 (25,7091.8 AU), sprint distance occurred during Week 43 (2337.5 AU), Acc occurred during Week 40 (85.6 AU), and Dec occurred during Week 39 (134.6 AU). Meanwhile the lowest value for TS through total distance was found during Week 20 (53,714.8 AU), sprint distance during Week 16 (204.5 AU), Acc during Week 10 (9.1 AU), and Dec during Week 33 (11.4 AU).

Table 1 shows the differences between starters and non-starters for TM and TS during the periods of the

Table 1. Differences between starters and non-starters during the periods of the season.

Measures	Pre-season (mean ± SD)	Early-season (mean ± SD)	Mid-season (mean ± SD)	End-season (mean ± SD)	Full-season (mean ± SD)
TM_{TD} (AU), ST	3.3 ± 0.3	4.8 ± 0.8	5.7 ± 2.6§	5.9 ± 2.3§	4.9 ± 1.1§
TM_{TD} (AU), NST	3.1 ± 0.5	4.6 ± 0.8	4.8 ± 1.6	5.0 ± 1.3	4.4 ± 0.7
TM_{SPRINT} (AU), ST	1.3 ± 0.3§	1.4 ± 0.1	2.3 ± 1.5§	1.6 ± 0.3§	1.6 ± 0.4§
TM_{SPRINT} (AU), NST	1.5 ± 0.5	1.5 ± 0.2	1.5 ± 0.2	1.7 ± 0.3	1.5 ± 0.1
TM_{Acc} (AU), ST	1.8 ± 0.3	1.8 ± 0.3	1.8 ± 0.1	2.0 ± 0.5§	1.9 ± 0.2§
TM_{Acc} (AU), NST	1.8 ± 0.1	1.8 ± 0.3	1.8 ± 0.4	1.9 ± 0.4	1.9 ± 0.2
TM_{Dec} (AU), ST	2.0 ± 0.3	1.8 ± 0.2	1.8 ± 0.2	1.8 ± 0.2§	1.9 ± 0.2
TM_{Dec} (AU), NST	1.8 ± 0.3	1.8 ± 0.1	1.7 ± 0.2	1.8 ± 0.3	1.8 ± 0.1
TS_{TD} (AU), ST	101,554.5 ± 16,129.9	101,662.1 ± 21,237.8	29,987.3 ± 6784.3	110,611.9 ± 18,322.9	85,953.9 ± 10,630.0
TS_{TD} (AU), NST	101,446.5 ± 14,550.6	90,163.3 ± 19,513.8	25,023.0 ± 6078.3	104,818.6 ± 34,086.0	80,362.8 ± 13,630.8
TS_{SPRINT} (AU), ST	735.0 ± 432.2§	355.3 ± 163.4	241.0 ± 109.3	1234.8 ± 430.7	641.5 ± 202.4
TS_{SPRINT} (AU), NST	994.0 ± 380.0	488.0 ± 187.7	214.7 ± 73.6	1268.4 ± 709.3	741.3 ± 277.6
TS_{Acc} (AU), ST	17.8 ± 8.15	14.5 ± 4.3	6.7 ± 2.7§	42.4 ± 29.5§	20.4 ± 9.9§
TS_{Acc} (AU), NST	21.3 ± 10.0	14.9 ± 5.7	7.5 ± 2.7	48.1 ± 25.4	23.0 ± 9.6
TS_{Dec} (AU), ST	20.1 ± 7.8	19.4 ± 3.7	8.9 ± 1.8	58.7 ± 36.5§	26.8 ± 11.1
TS_{Dec} (AU), NST	29.2 ± 14.5	24.8 ± 9.0	10.5 ± 2.2	69.0 ± 24.6	33.4 ± 6.9

TM: training monotony; TS: training strain; AU: arbitrary units; ST: starters; NST: non-starters; TD: total distance; SPRINT: sprint distance; Acc: accelerations; Dec: decelerations.
§Performed by Mann–Whitney test.

season: TM_{TD}, $F(2.074, 35.261) = 0.364$, $p = 0.705$, $\eta_p^2 = 0.021$; TM_{SPRINT}, $F(1.424, 24.216) = 2.605$, $p = 0.109$, $\eta_p^2 = 0.133$; TM_{Acc}, $F(2.104, 35.771) = 0.046$, $p = 0.961$, $\eta_p^2 = 0.003$; TM_{Dec}, $F(2.135, 36.294) = 0.772$; $p = 0.477$, $\eta_p^2 = 0.043$; TS_{TD}, $F(2.370, 40.284) = 0.372$, $p = 0.727$, $\eta_p^2 = 0.021$; TS_{SPRINT}, $F(1.802, 30.641) = 0.715$, $p = 0.484$, $\eta_p^2 = 0.040$; TS_{Acc}, $F(1.154, 19.617) = 0.176$, $p = 0.715$, $\eta_p^2 = 0.010$; and TS_{Dec}, $F(1.255, 21.340) = 0.268$, $p = 0.663$, $\eta_p^2 = 0.016$.

Table 2 presents the differences between playing positions during the periods of the season. No significant differences were found for TM_{TD}, $F(8.074, 28.258) = 1.267$, $p = 0.299$; $\eta_p^2 = 0.266$; TM_{Acc}, $F(9.302, 32.557) = 0.894$, $p = 0.544$, $\eta_p^2 = 0.203$; TM_{Dec}, $F(8.551, 29.928) = 2.128$; $p = 0.061$, $\eta_p^2 = 0.378$; TS_{TD}, $F(9.433, 33.017) = 0.764$, $p = 0.655$; $\eta_p^2 = 0.179$; TS_{SPRINT}, $F(6.487, 22.706) = 0.647$, $p = 0.703$, $\eta_p^2 = 0.156$; TS_{Acc}, $F(4.618, 16.164) = 0.862$, $p = 0.520$, $\eta_p^2 = 0.198$; and TS_{Dec}, $F(4.839, 16.938) = 0.629$, $p = 0.675$, $\eta_p^2 = 0.152$. However, a one-way ANOVA revealed that there were statistically significant differences in TM_{SPRINT}, $F(7.438, 26.034) = 5.963$, $p < 0.001$, $\eta_p^2 = 0.630$ between at least two groups. Thus, multiple comparisons revealed that in mid-season this measure was meaningfully greater for CD than WD ($p = 0.006$; $g = 1.74$ [0.06, 3.95]), CM ($p = 0.002$; $g = 2.04$ [0.28, 4.46]), WM ($p = 0.005$; $g = 1.78$ [0.09, 4.02]), and ST ($p = 0.002$; $g = 2.05$ [0.28, 4.46]). Regarding full-season, TM_{SPRINT} was significantly greater for CD than WD ($p = 0.031$; $g = 1.59$ [−0.04, 3.73]), CM ($p = 0.011$; $g = 1.83$ [0.13, 4.11]), and ST ($p = 0.023$; $g = 1.52$ [−0.10, 3.59]).

In Table 2, it is also possible to see the differences between the periods of the season (pre, early, mid, and end-season), independently of the player status or the playing positions. No significant difference was found for TM_{Dec} ($F(2.144, 38.596) = 1.251$, $p = 0.152$, $\eta_p^2 = 0.299$); TM_{SPRINT} ($F(1.361, 24.490) = 2.131$, $p = 0.152$, $\eta_p^2 = 0.106$); and for TM_{ACC} ($F(2.103, 37.862) = 1.402$, $p = 0.259$, $\eta_p^2 = 0.072$).

Firstly, TM_{TD} revealed significant differences between at least two periods ($F(2.080, 37.447) = 11.260$, $p < 0.001$, $\eta_p^2 = 0.385$). After this, TM_{TD} was meaningfully greater in early-season than pre-season ($p < 0.001$; $g = -2.26$ [−3.12, −1.46]); greater in mid-season than pre-season ($p < 0.001$; $g = -1.32$ [−2.05, −0.63]); greater in full-season than pre-season ($p < 0.001$; $g = -1.89$ [−2.69, −1.14]); greater in mid-season than early-season ($p < 0.001$; $g = 0.37$ [−0.26, 1.02]), greater in end-season than mid-season ($p < 0.001$; $g = -0.06$ [−0.70, 0.56]), greater in mid-season than full-season ($p < 0.001$; $g = 0.32$ [−0.31, 0.96]), and greater in end-season than full-season ($p < 0.001$; $g = 0.48$ [−0.15, 1.13]).

TS_{TD} displayed significant differences between at least two periods ($F(2.374, 42.726) = 99.317$, $p < 0.001$, $\eta_p^2 = 0.847$). In this sense, TS_{TD} was meaningfully greater in pre-season than mid-season ($p < 0.001$; $g = 6.22$ [4.75, 7.94]); greater in pre-season than full-season ($p < 0.001$; $g = 1.31$ [0.62, 2.03]); greater in early-season than mid-season ($p < 0.001$; $g = 4.35$ [3.23, 5.64]); greater in early-season than full-season ($p = 0.001$; $g = 0.74$ [0.09, 1.41]); greater in end-season than mid-season ($p < 0.001$; $g = -4.09$ [−5.32, −3.01]); greater in full-season than mid-season ($p < 0.001$; $g = -5.54$ [−7.10, −4.21]); and greater in end-season than full-season ($p < 0.001$; $g = 1.17$ [0.49, 1.88]).

TS_{SPRINT} exhibited significant differences between at least two periods ($F(1.858, 33.439) = 39.252$, $p < 0.001$,

Table 2. Differences between playing positions and between periods of the season.

Measures	Pre-season (Mean ± SD)	Early-season (Mean ± SD)	Mid-season (Mean ± SD)	End-season (Mean ± SD)	Full-Season (Mean ± SD)	Inferential statistics	p value (between periods)
TM_{TD} (AU), CD	3.5 ± 0.17	4.4 ± 0.6	7.5 ± 4.5	6.0 ± 2.6	5.4 ± 1.9	$T = -7.1$	**PreS vs EarS: < 0.001**
						$Z = -3.8$	**PreS vs MidS: < 0.001**§
TM_{TD} (AU), WD	3.4 ± 0.09	4.4 ± 0.2	5.1 ± 0.6	4.3 ± 0.9	4.3 ± 0.2	$Z = -1.5$	PreS vs EndS: 0.126§
						$Z = -3.6$	**PreS vs FullS: < 0.001**§
TM_{TD} (AU), CM	3.0 ± 0.44	5.4 ± 0.9	5.8 ± 2.3	7.1 ± 2.5	5.3 ± 0.8	$Z = -3.8$	**EarS vs MidS: < 0.001**§
						$Z = -1.9$	EarS vs EndS:0.059§
TM_{TD} (AU), WM	3.2 ± 0.32	4.5 ± 1.0	4.5 ± 0.5	5.4 ± 1.6	4.4 ± 0.5	$Z = -3.0$	**EarS vs FullS: 0.003**§
						$Z = -3.8$	**MidS vs EndS: < 0.001**§
TM_{TD} (AU), ST	3.0 ± 0.75	4.6 ± 1.0	4.2 ± 0.8	4.5 ± 1.3	4.1 ± 0.8	$Z = -3.8$	**MidS vs FullS: < 0.001**§
						$Z = -3.8$	**EndS vs FullS: < 0.001**§
TM_{TD} (AU), TEAM	3.2 ± 0.43	4.68 ± 0.81	5.30 ± 2.16	5.45 ± 1.93	4.66 ± 0.98		
TM_{SPRINT} (AU), CD	1.3 ± 0.19	1.3 ± 0.1	4.0 ± 1.7^{a,b,c,d}	1.8 ± 0.5	2.1 ± 0.5^{a,b,d}	$Z = -1.0$	PreS vs EarS: 0.295§
						$Z = -1.7$	PreS vs MidS: 0.099§
TM_{SPRINT} (AU), WD	1.5 ± 0.38	1.4 ± 0.2	1.7 ± 0.3	1.5 ± 0.2	1.5 ± 0.1	$Z = -2.4$	**PreS vs EndS: 0.019**§
						$Z = -2.1$	**PreS vs FullS: 0.030**§
TM_{SPRINT} (AU), CM	1.2 ± 0.12	1.6 ± 0.2	1.3 ± 0.1	1.6 ± 0.2	1.4 ± 0.1	$Z = -0.6$	EarS vs MidS: 0.546§
						$T = -2.0$	EarS vs EndS: 0.054
TM_{SPRINT} (AU), WM	1.5 ± 0.16	1.5 ± 0.2	1.6 ± 0.2	1.8 ± 0.2	1.6 ± 0.04	$Z = -1.5$	EarS vs FullS: 0.136§
						$Z = -0.2$	MidS vs EndS: 0.862§
TM_{SPRINT} (AU), ST	1.6 ± 0.73	1.5 ± 0.1	1.3 ± 0.1	1.6 ± 0.3	1.5 ± 0.2	$Z = -0.6$	MidS vs FullS: 0.533§
						$Z = -0.9$	EndS vs FullS: 0.334§
TM_{SPRINT} (AU), TEAM	1.41 ± 0.38	1.47 ± 0.17	1.88 ± 1.13	1.63 ± 0.28	1.59 ± 0.29		
TM_{Acc} (AU), CD	2.0 ± 0.49	2.1 ± 0.2	1.8 ± 0.1	1.8 ± 0.1	1.9 ± 0.2	$T = -0.3$	PreS vs EarS: 0.804
						$T = 0.3$	PreS vs MidS: 0.761
TM_{Acc} (AU), WD	1.8 ± 0.19	1.7 ± 0.4	1.8 ± 0.2	2.3 ± 0.7	1.9 ± 0.2	$Z = -1.8$	PreS vs EndS: 0.064§
						$Z = -0.9$	PreS vs FullS: 0.376§
TM_{Acc} (AU), CM	1.7 ± 0.21	1.7 ± 0.2	1.7 ± 0.1	1.9 ± 0.2	1.8 ± 0.03	$T = 0.5$	EarS vs MidS: 0.544
						$Z = -0.9$	EarS vs EndS: 0.344§
TM_{Acc} (AU), WM	1.9 ± 0.15	1.8 ± 0.3	1.8 ± 0.3	1.8 ± 0.4	1.8 ± 0.2	$Z = -0.2$	EarS vs FullS: 0.809§
						$Z = -1.7$	MidS vs EndS:0.098§
TM_{Acc} (AU), ST	1.8 ± 0.09	1.9 ± 0.2	1.8 ± 0.5	2.0 ± 0.6	1.9 ± 0.3	$Z = -1.4$	MidS vs FullS: 0.171§
						$Z = -2.1$	**EndS vs FullS: 0.036**§
TM_{Acc} (AU), TEAM	1.82 ± 0.23	1.84 ± 0.27	1.79 ± 0.25	1.97 ± 0.44	1.86 ± 0.18		
TM_{Dec} (AU), CD	1.8 ± 0.28	1.9 ± 0.2	1.9 ± 0.3	1.7 ± 0.1	1.8 ± 0.1	$Z = -1.4$	PreS vs EarS: 0.153§
						$Z = -1.2$	PreS vs MidS: 0.231§
TM_{Dec} (AU), WD	2.0 ± 0.29	1.8 ± 0.3	1.9 ± 0.2	1.9 ± 0.3	1.9 ± 0.2	$Z = -0.9$	PreS vs EndS: 0.365§
						$Z = -1.3$	PreS vs FullS: 0.184
TM_{Dec} (AU), CM	2.0 ± 0.30	1.7 ± 0.1	1.7 ± 0.2	1.7 ± 0.1	1.8 ± 0.1	$T = 0.1$	EarS vs MidS: 0.990
						$T = -0.3$	EarS vs EndS: 0.766
TM_{Dec} (AU), WM	2.1 ± 0.13	1.8 ± 0.1	1.6 ± 0.1	1.8 ± 0.4	1.8 ± 0.1	$T = -1.25$	EarS vs FullS: 0.226
						$T = -0.3$	MidS vs EndS: 0.796

(continued)

Table 2. (continued)

Measures	Pre-season (Mean ± SD)	Early-season (Mean ± SD)	Mid-season (Mean ± SD)	End-season (Mean ± SD)	Full-Season (Mean ± SD)	Inferential statistics	p value (between periods)
TM_{Dec} (AU), ST	1.6 ± 0.1	1.8 ± 0.1	1.9 ± 0.1	1.9 ± 0.2	1.8 ± 0.1	$T = -0.8$	MidS vs FullS: 0.390
						$T = -0.4$	EndS vs FullS: 0.720
TM_{Dec} (AU), TEAM	1.90 ± 0.28	1.79 ± 0.15	1.79 ± 0.20	1.80 ± 0.26	1.82 ± 0.13		
TS_{TD} (AU), CD	113586.5 ± 14885.11	108246.4 ± 14011.3	30925.0 ± 12160.6	110311.0 ± 14282.6	90767.2 ± 5158.9	$T = 0.9$	PreS vs EarS: 0.376
						$T = 20.9$	**PreS vs MidS: < 0.001**
TS_{TD} (AU), WD	98726.5 ± 16645.01	82708.9 ± 10933.1	30227.5 ± 6036.9	101552.8 ± 23782.3	78303.9 ± 13489.5	$T = -0.9$	PreS vs EndS: 0.333
						$T = 5.4$	**PreS vs FullS: < 0.001**
TS_{TD} (AU), CM	95990.8 ± 12695.78	107457.3 ± 29932.5	27069.9 ± 3394.6	125032.4 ± 7713.2	88887.6 ± 5756.1	$T = 15.5$	**EarS vs MidS: < 0.001**
						$T = -2.0$	EarS vs EndS: 0.058
TS_{TD} (AU), WM	107132.3 ± 19466.7	92233.9 ± 16845.1	26464.2 ± 6973.1	108580.6 ± 42864.3	83602.8 ± 12523.5	$T = 3.8$	**EarS vs FullS: 0.001**
						$T = -14.8$	**MidS vs EndS: < 0.001**
TS_{TD} (AU), ST	95101.4 ± 19466.7	93437.7 ± 23649.6	24314.6 ± 6602.7	94472.3 ± 29464.0	76831.5 ± 17537.0	$T = -25.5$	**MidS vs FullS: < 0.001**
						$T = 6.3$	**EndS vs FullS: < 0.001**
TS_{TD} (AU), TEAM	101503.33 ± 14972.89	96215.29 ± 20725.75	27635.76 ± 6776.35	107867.67 ± 26326.34	83305.51 ± 12136.78		
TS_{SPRINT} (AU), CD	512.6 ± 128.8	227.8 ± 8.7	232.3 ± 109.3	1226.3 ± 148.4	549.7 ± 47.6	$T = 5.2$	**PreS vs EarS: < 0.001**
						$T = 6.5$	**PreS vs MidS: < 0.001**
TS_{SPRINT} (AU), WD	1055.5 ± 536.8	486.7 ± 159.3	318.8 ± 94.4	1399.1 ± 595.9	815.0 ± 170.99	$T = -2.7$	**PreS vs EndS: 0.013**
						$T = 2.3$	**PreS vs FullS: 0.029**
TS_{SPRINT} (AU), CM	625.1 ± 262.8	313.7 ± 115.1	146.2 ± 41.7	993.6 ± 332.0	519.6 ± 159.5	$T = 5.3$	**EarS vs MidS: < 0.001**
						$T = -7.5$	**EarS vs EndS: < 0.001**
TS_{SPRINT} (AU), WM	1253.0 ± 267.2	581.3 ± 188.7	247.6 ± 84.8	1597.0 ± 941.0	919.7 ± 301.0	$T = -8.2$	**EarS vs FullS: < 0.001**
						$T = -8.4$	**MidS vs EndS: < 0.001**
TS_{SPRINT} (AU), ST	755.8 ± 382.5	433.8 ± 186.4	198.7 ± 62.9	1031.7 ± 438.9	605.0 ± 195.5	$T = -9.7$	**MidS vs FullS: < 0.001**
						$T = 6.4$	**EndS vs FullS: < 0.001**
TS_{SPRINT} (AU), TEAM	857.66 ± 418.63	418.16 ± 183.43	228.53 ± 92.51	1250.75 ± 562.71	686.77 ± 239.49		
TS_{Acc} (AU), CD	12.4 ± 5.5	15.0 ± 2.4	6.0 ± 0.8	28.0 ± 9.6	15.4 ± 4.1	$T = 2.9$	**PreS vs EarS: 0.008**
						$z = -3.8$	**PreS vs MidS: < 0.001**§
TS_{Acc} (AU), WD	24.5 ± 8.5	15.3 ± 5.8	8.4 ± 3.8	62.7 ± 39.3	27.7 ± 12.3	$z = -3.6$	**PreS vs EndS: < 0.001**§
						$z = -2.1$	**PreS vs FullS: < 0.001**§
TS_{Acc} (AU), CM	15.2 ± 2.3	12.2 ± 4.0	5.2 ± 0.6	32.9 ± 11.1	16.4 ± 3.8	$z = -3.8$	**EarS vs MidS: < 0.001**§
						$z = -3.7$	**EarS vs EndS: < 0.001**§
TS_{Acc} (AU), WM	26.2 ± 7.2	17.7 ± 5.1	9.0 ± 2.9	50.9 ± 25.9	25.9 ± 7.6	$z = -3.3$	**EarS vs FullS: 0.001**
						$z = -3.8$	**MidS vs EndS: < 0.001**§
TS_{Acc} (AU), ST	17.3 ± 12.1	13.5 ± 6.3	6.6 ± 2.2	46.7 ± 32.2	21.0 ± 13.0	$z = -3.8$	**MidS vs FullS: < 0.001**§
						$z = -3.7$	**EndS vs FullS: < 0.001**§
TS_{Acc} (AU), TEAM	19.47 ± 8.84	14.69 ± 4.86	7.09 ± 2.63	45.09 ± 27.03	21.59 ± 9.59		
TS_{Dec} (AU), CD	17.1 ± 5.0	17.7 ± 1.0	8.7 ± 1.5	49.0 ± 25.3	23.1 ± 7.5	$Z = -0.8$	PreS vs EarS: 0.421§
						$Z = -3.7$	**PreS vs MidS: < 0.001**§
TS_{Dec} (AU), WD	23.1 ± 9.6	20.4 ± 4.2	9.4 ± 1.9	76.1 ± 50.3	32.2 ± 14.2	$Z = -3.5$	**PreS vs EndS: < 0.001**§
						$Z = -2.2$	**PreS vs FullS: 0.027**§

(continued)

Table 2. (continued)

Measures	Pre-season (Mean ± SD)	Early-season (Mean ± SD)	Mid-season (Mean ± SD)	End-season (Mean ± SD)	Full-Season (Mean ± SD)	Inferential statistics	*p* value (between periods)
TS_{Dec} (AU), CM	25.6 ± 14.6	20.7 ± 4.8	8.4 ± 1.8	48.3 ± 19.9	25.7 ± 9.4	$Z = -3.8$ $Z = -3.6$ $Z = -3.0$ $T = -7.8$ $T = -10.1$ $T = 6.4$	**EarS vs MidS: < 0.001**§ **EarS vs EndS: < 0.001**§ **EarS vs FullS: < 0.001**§ **MidS vs EndS: < 0.001** **MidS vs FullS: < 0.001** **EndS vs FullS: < 0.001**
TS_{Dec} (AU), WM	36.7 ± 14.5	25.8 ± 9.4	10.1 ± 2.3	74.5 ± 36.9	36.8 ± 6.6		
TS_{Dec} (AU), ST	17.9 ± 5.3	24.2 ± 11.1	11.3 ± 2.3	66.5 ± 12.6	30.0 ± 7.2		
TS_{Dec} (AU), TEAM	24.40 ± 12.09	21.96 ± 7.11	9.27 ± 2.09	63.58 ± 31.03	29.89 ± 9.69		

TM: training monotony; TS: training strain; AU: arbitrary units; TD: total distance; SPRINT: sprint distance; Acc: accelerations; Dec: decelerations; CD: central defenders; WD: wide defenders; CM: central midfielders; WM: wide midfielders; ST: strikers.
Significant differences between periods are highlighted in bold ($p \leqslant 0.05$).
[a]Denotes significant difference with WM.
[b]Denotes significant difference with CM.
[c]Denotes significant difference with WM.
[d]Denotes significant difference with ST.
[§]Performed by Mann–Whitney test.

$\eta_p^2 = 0.686$). Hence, TS_{SPRINT} was significantly greater in early-season than pre-season ($p < 0.001$; $g = 1.33$ [0.64, 2.06]); greater in mid-season than pre-season ($p < 0.001$; $g = 2.03$ [1.27, 2.86]); greater in end-season than pre-season ($p = 0.013$; $g = -0.78$ [−1.44, −0.12]); greater in pre-season than full-season ($p = 0.029$; $g = 0.48$ [−0.15, 1.13]); greater in mid-season than early-season ($p < 0.001$; $g = 1.28$ [0.59, 2.00]); greater in end-season than early-season ($p < 0.001$; $g = -1.95$ [−2.76, −1.19]); greater in full-season than early-season ($p < 0.001$; $g = -1.24$ [−1.96, −0.56]); greater in mid-season than end-season ($p < 0.001$; $g = -2.48$ [−3.38, −1.66]); greater in mid-season than full-season ($p < 0.001$; $g = -2.48$ [−3.38, −1.66]); and greater in end-season than full-season ($p < 0.001$; $g = 1.27$ [0.59, 1.99]).

TS_{Acc} showed significant differences between at least two periods ($F(1.157, 20.827) = 32.844$, $p < 0.001$, $\eta_p^2 = 0.646$). TS_{Acc} was meaningfully greater in pre-season than early-season ($p = 0.008$; $g = 0.65$ [0.01, 1.32]); greater in pre-season than mid-season ($p < 0.001$; $g = 1.86$ [1.12, 2.66]); greater in end-season than pre-season ($p < 0.001$; $g = -1.25$ [−1.97, −0.57]); greater in early-season than mid-season ($p < 0.001$; $g = 1.91$ [1.16, 2.72]); greater in full-season than pre-season season ($p < 0.001$; $g = 0.22$ [−0.41, 0.86]); greater in early-season than mid-season season ($p < 0.001$; $g = 1.90$ [1.16, 2.71]); greater in end-season than early-season ($p < 0.001$; $g = -1.53$ [−2.29, −0.83]); greater in full-season than early-season ($p = 0.001$; $g = -0.89$ [−1.57, −0.23]); greater in end-season than mid-season ($p < 0.001$; $g = -1.94$ [−2.75, −1.19]); greater in full-season than mid-season ($p < 0.001$; $g = -2.02$ [−2.84, −1.26]); and greater in end-season than full-season ($p < 0.001$; $g = 1.13$ [0.46, 1.84]).

Finally, the TS_{Dec} exhibited significant differences between at least two periods ($F(1.276, 22.799) = 39.553$, $p < 0.001$, $\eta_p^2 = 0.687$). TS_{Dec} was significantly greater in full-season than pre-season ($p = 0.027$; $g = 0.49$ [−0.14, 1.14]), greater in pre-season than mid-season ($p < 0.001$; $g = 1.66$ [0.95, 2.44]); greater in end-season than pre-season ($p = 0.002$; $g = -1.63$ [−2.39, −0.91]); greater in early-season than mid-season ($p < 0.001$; $g = 2.31$ [1.51, 3.18]); greater in end-season than early-season ($p < 0.001$; $g = -1.81$ [−2.61, −1.08]); greater in full-season than early-season ($p = 0.030$; $g = -0.91$ [−1.59, −0.26]); greater in end-season than mid-season ($p < 0.001$; $g = -2.40$ [−3.29, −1.59]); greater in full-season than mid-season ($p < 0.001$; $g = -2.82$ [−3.79, −1.96]); and greater in end-season than full-season ($p < 0.001$; $g = 1.43$ [0.74, 2.17]).

Discussion

The aims of this study were to compare the weekly variations of training monotony (TM) and training strain

(TS) through total distance and high intensity variables (sprint distance, accelerations (Acc, $>4\,m\,s^{-2}$), and decelerations (Dec, $<4\,m\,s^{-2}$)) among periods of the season, playing status and playing positions. The main results showed that TM_{TD} was significantly different in all periods with only one exception between early-season and end-season. The TM_{SPRINT} was significantly lower in pre-season than end-season and full-season. The TM_{Acc} was also significantly lower in pre-season than full-season. TS_{TD} was significantly different in all periods with three exceptions between pre-season and early-season, between pre-season and end-season and between early-season and end-season. TS through sprint and ACC were significantly different in all periods. Lastly, TS_{Dec} was significantly different in all periods with only one exception between pre-season and early-season. The second aim of this study was focused on playing status comparison and showed no significant differences between starters and non-starters. The results of the present study also showed that TM and TS of sprint distance in mid-season were meaningfully greater for CD than the remaining positions.

The outcomes of the period's comparisons may be related to the number of matches and training sessions performed in mid-season or the cumulative effects of mental and physical fatigue owing to the multiplicity of matches during the competition season. While some studies[26,29,30] have highlighted higher training loads in pre-season due to a focus on improving physical conditioning, the present data was in line with Clemente et al. where the highest variation in TM was observed in the end-season over the early-season throughout a 45-week macrocycle.[12] In European elite players, greater TS of high-speed running was also shown at the end of the season.[13] Concerning the pattern of the graphs (Figures 2 and 3), TM and TS of sprint distance, Acc, and Dec also established a similar fluctuating pattern with total distance across the season with a tendency to higher values in the mid and/or end-season. For instance, higher values of TM_{SPRINT} occurred on Week 20 (5.05 = AU), for Acc and Dec occurred on Week 40 (2.79 and 2.44 = AU, respectively) and higher values of TS_{SPRINT} occurred on Week 43 (2337.54 = AU), for Acc occurred on Week 40 (85.60 = AU), and for Dec occurred on Week 39 (134.56 = AU). Overall, during pre- and mid-season, little variation in TM and TS were observed between mesocycles through total distance, sprint distance, Acc, and Dec. Contrary to the present observations, there were some studies[15,30] that reported highest TM and TS of distance-based indices in pre-season which is considered a crucial period to develop physical qualities to meet the required level of physical demands during match play through a higher training load.[31] Other evidence on TM and TS also revealed trivial effects on soccer training performance and somewhat ambiguous nature across the season[32] which depends on distinctive contextual factors.[33]

Some studies observed a fluctuating pattern between mesocycles.12·17 This type of pattern may help to justify training load adjustments to reduce differences according to the player status. The present research did not observe a fluctuating pattern between mesocycles. This pattern was evident only in the middle of end-season and continued until the final week for TS of sprint distance, Acc, and Dec (Figure 3). It might be due to a better loading strategy in the end-season or other contextual co-variables. A previous study concluded that training load distribution throughout the week varied considerably according to match-contextual factors such as match location, results, and opponent quality.[33]

With respect to variations of TM and TS between playing status during different periods of season, no significant differences were found between starters and non-starters regarding total distance, sprint distance, Acc, and Dec. Given that most coaching staff formulate appropriate loading strategies, it was confirmed that all players experienced the same loads in training, while match load only accounts for a small proportion of overall load and did not contribute to significant changes. In line with the results of the present study, Oliveira et al. reported no significant differences for TM and TS of total distance and high-speed running, when players were grouped according to their playing status as starters or non-starters.[13] Considering that some of these loading indices are sensitive to load fluctuations, it is reasonable to expect participation, or lack thereof, in soccer matches may influence the workload measures. However, similar to results reported by Oliveira et al.,[13] distance-based measurements in the present study may not be sensitive enough to perceive probable playing status-related differences in monitoring monotony and strain in training routines. Although the present results did not show a statistically significant difference here, depending on player status, it was found that players had a different understanding of the loads in different mesocycles across the season. This finding was associated to the amount and type of players' response to the training stimulus, which is different for each training indicator.[5] Inconsistent results were also provided by a previous report,[16] where TM and TS from accelerometer-derived variables indicated greater values for starters in comparison with their non-starter peers. Non-starter players in the Chinese Super League also experienced greater workloads than starters or whole-match players.[34] These contradictory results come from the somewhat ambiguous nature of monitoring training load which could be related to the distinctive nature of contextual factors such as match location, match results, and quality of opponents.[33] Taken together, while it might be time-consuming, the present data further underlined the need for appropriate monitoring of individuals within a team environment and proposed that an individualized approach may provide more noteworthy and practical information regarding monitoring training load.

With respect to variations of TM and TS through total distance, sprint distance, Acc, and Dec between playing positions across different periods of season, there were only significant differences for TM through sprint distance in mid-season. Among players, CD were found to represent significantly less TM $_{\mathrm{SPRINT}}$ than any other playing positions. Significant differences between playing positions in load measures are well documented in previous studies.[17,35,36] For example, a more recent study by Oliveira et al. revealed that there were significant differences of TM through high-speed running in Mesocycle 3 (4 weeks, 18 training sessions, 4 matches) between CD versus CM, and in Mesocycle 4 (4 weeks, 18 training sessions, 5 matches) between CD versus WM, WD versus CM, and WD versus ST, while players in the present study incurred a more congested calendar in Mesocycle 6 (4 weeks, 20 training sessions, 8 matches).[17] Interestingly, a difference was detected in the mid-season where the highest number of training sessions and matches (12 weeks, 50 training sessions and 17 matches) occurred during the season. Since TM refers to the variation or sameness of the perceived load,[37] this result highlights that a lack of variety in training regimen may occur in a congested (weeks with more than one match) or less congested calendar for players with different playing positions. Consequently, the results of the present study are in line with others[38] emphasizing the need for the intelligent use of rest days and training variety for different playing positions to avoid boredom and high monotony regardless of whether or not a team's calendar is full. The present findings also revealed no meaningful differences for TM of total distance, Acc and Dec, and TS. Similar results were found in a recent study by Clemente et al.[12], which concluded that indices are not significantly different from position to position. Divergent results on indices concerning different playing positions could exist, depending on distance covered in the training session or competitions, different intensity zones of external measures and some contextual co-variables that should be considered in future studies.

The present study has some limitations that should be listed. The number of subjects included in this study was small and it belonged to only one football team. In addition, no measurements were made regarding the injury rate, fatigue, recovery process and wellbeing of the players; internal measures, such as rated perceived exertion, were not considered in the present research. Finally, previous research showed some validity and reliability issues in the GPS model used.[6] Therefore, all data should be cautiously interpreted. Future research should avoid the previous limitations to provide more robust information about the indices used by the present study. Moreover, it is suggested that internal measures be utilized to provide a broader view of the load distribution of the players regarding playing status and position. Lastly, and considering that no differences were found between playing status, and only few were found between playing position in TM and TS, we suggest as a practical application for coaches and their staff, the individual analysis (player by player) of such indexes. Such analysis can also be considered in future research.

Conclusion

The result of this study revealed that during pre- and mid-season, there was little variation in TM and TS between mesocycles for total distance and high intensity variables. The findings emphasized the need for the intelligent use of rest days and training variety for different playing positions to avoid boredom and high monotony. In conclusion, the indices measured in the present study may not be sensitive enough to determine probable playing status and playing positions related differences in monitoring monotony and strain. Further investigations are needed to provide a deeper understanding of load monitorization with respect to the sensitivity of other external and internal load measures to compare the potential differences between periods, playing status and positions.

Author contributions

Conceptualization, H.N., A.B., A.D.M., and R.O.; Formal analysis, H.N., A.D.M., and R.O.; Funding acquisition, H.N., A.D.M., and R.O.; Methodology, H.N., A.B., A.D.M., and R.O; Software, H.N., A.D.M., and R.O.; Writing–original draft, H.N., A.B., A.D.M., and R.O.; Writing–review & editing, H.N., A.B., A.D.M., and R.O. All authors have read and agreed to the published version of the manuscript.

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Ethical approval and consent to participants

To engage in this study, both the players and their coaching staff signed an informed consent form. The study has been approved by the University of Mohaghegh Ardabili Ethics Committee prior to its start, and the Helsinki Declaration was used to follow the recommendations of Human Ethics in Research.

Consent for publication

Not applicable.

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Data availability statement

The datasets generated and analyzed during the current study are available from the corresponding authors on reasonable request.

Supplemental material

Supplemental material for this article is available online.

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