

# Variations of external workload across a soccer season for starters and non-starters

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## Abstract

The aims of this study were to (i) analyze within-group (starters and non-starters) for the weekly acute (wAW), chronic (wCW), and acute:chronic workload ratio (wACWR) throughout the pre-, early-, mid-, and end-season periods, and (ii) analyze the within-group differences for the weekly total distance (wTD), sprint total distance (wSTD), high-speed running distance (wHSRd), and repeated sprint (wRS) throughout the soccer season. The study included a professional soccer team that participated in the highest level of the Iranian Persian Gulf Pro League during a full season. A Global Positioning System was used for data collection during the study. Results revealed significant differences between season periods for wAW and wACWR for both starters (wAW:  $p = 0.003$ ,  $\eta_p^2 = 0.541$ ; wACWR:  $p < 0.001$ ,  $\eta_p^2 = 0.964$ ) and non-starters (wAW:  $p < 0.001$ ,  $\eta_p^2 = 0.696$ ; wACWR:  $p < 0.001$ ,  $\eta_p^2 = 0.943$ ). Only non-starters had meaningful differences for wCW ( $p = 0.009$ ,  $\eta_p^2 = 0.408$ ). There were significant differences in wTD and wSTD for both starters (wTD:  $p < 0.001$ ,  $\eta_p^2 = 0.810$ ; wSTD:  $p = 0.014$ ,  $\eta_p^2 = 0.457$ ) and non-starters (wTD:  $p < 0.001$ ,  $\eta_p^2 = 0.895$ ; wSTD:  $p < 0.001$ ,  $\eta_p^2 = 0.781$ ). Only non-starters showed significant differences ( $p < 0.001$ ,  $\eta_p^2 = 0.722$ ) for wRS, while both groups showed no significant differences for wHSRd. In conclusion, these results revealed that both groups experienced significant differences in wAW, wACWR, wTD, and wSTD, while non-starters presented significant differences in wCW and wRS. Coaches should consider these group differences when planning training sessions. Exposure to wSTD and wRS should be addressed for non-starters, as well as fatigue monitoring for starters, especially for players with full match participation.

## Keywords

High-speed, performance, workload monitoring, starter, fatigue, soccer

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## Introduction

Training and match load quantification, as well as the systematic monitoring of such workloads, have been promoted in soccer in the past few years.<sup>1</sup> It is a well-established research interest and practice within the sports science community, with the aim to better assist coaches when it comes to planning and making adjustments in the training process.<sup>2</sup>

A consistent communication bridge between all departments involved in an elite soccer team must be ensured.<sup>3</sup> This way, clear and objective information regarding the athletes' current state can be shared between departments so as to potentially reduce the risk of injury occurrence or illness.<sup>3</sup> Thus, it is of paramount importance to know how athletes are responding to training, realizing that the acute and chronic

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loads are the most important external load measures used in soccer.<sup>4</sup> Also, monitoring weekly training loads and match demands represents a crucial role to avoid sudden workload increases beyond the player's capacity to tolerate such exposures.<sup>5</sup>

Training workload quantification and monitoring allow practitioners and coaches to ensure that principles such as progressive overload, individualization, and load variation are being contemplated.<sup>6</sup> Thus, training and match load quantification is represented by two main dimensions: (i) external workload – the demands imposed on athletes by training, and (ii) internal workload – the athletes' responses to those imposed demands. In soccer, as in other outdoor team sports, the external workloads are usually quantified via diverse Global Positioning System (GPS) methods of data collection.<sup>7,8</sup> Typically, GPS devices allow quantifying distance-based measures, such as total distance and distances covered at different speed-rates. Also, those devices typically have integrated accelerometers, which provide coaches and practitioners accelerometry-based measures, such as player load (sum of accelerations and decelerations), impacts, and stride.<sup>9</sup> The distance-based measures and changes in speed can be highly dependent on tactical problems,<sup>10</sup> while the measures derived from the inertial sensors/accelerometers seem to be independent of players' activities during training and matches, and can be used to monitor fatigue levels.<sup>11</sup> Indeed, the inertial sensor/accelerometer measures have been associated with the presence of neuromuscular fatigue, which can lead to increased levels of leg stiffness, decreased running mechanics, and consequently, increased step frequency.<sup>12</sup>

As such, the player-load metric, which gathers the accelerometer tri-axial movement data (the accumulated data of anteroposterior, mediolateral, and cranio-caudal axes), has been widely used in professional soccer teams.<sup>13–15</sup> This metric englobes high-impact activities, such as accelerations, decelerations, changes of direction, and collisions, that are usually imposed on athletes during training and competition.<sup>16</sup> Despite the great interest in using this type of metric, some issues have been addressed.<sup>17</sup> However, considering the above-mentioned relationships with increased fatigue levels and accelerometry-based measures, it is of paramount importance to monitor weekly training and match loads imposed on players. Based on that, a new player-load (NPL) metric, calculated from the accelerometer data, was designed to reflect both the volume and intensity of accelerations. This metric was previously used as a training load and work rate marker, as well as an innovative way of processing the weekly acute (wAW), chronic (wCW), and acute:chronic ratio (wACWR) workloads.<sup>18</sup>

Furthermore, given the long duration of a professional soccer season, meaningful training workload variations are expected to occur throughout the season. In fact, several studies have documented greater workloads for both distance-based and accelerometry-based

measures during the pre-season (PreS), compared to mid-season (MidS) and end-season (EndS) periods.<sup>14,19</sup> For example, in the study by Clemente et al.<sup>19</sup> which examined external workload fluctuations over a full season, they reported that wAW, training monotony (related to loading variation), and strain (related to loading tension) during the PreS were greater than the MidS and EndS, whereas the sprint total distance (STD) and high-speed running distance (HSRd) values were greater for MidS and EndS as compared to PreS. Clemente et al.<sup>19</sup> did not report any significant difference in the number of repeated sprints (RS). Commonly, available research regarding soccer external workload quantification analyzes seasonal team profiles without addressing the possible weekly load differences between periods of the season or player type (starters and non-starters). However, a study conducted on 19 elite soccer players analyzed distance-based measures during congested fixtures, considering different levels of match participation.<sup>20</sup> This study revealed that players participating in more than one match per week presented greater weekly loads for the overall distance metrics than players with lesser match participation.<sup>20</sup> However, the authors did not analyze those differences considering different periods of the season. This should be a call for further investigation on the weekly workload profiles of players with partial match participation between different season periods, as load imbalances seem to occur between starters and non-starters for the most commonly used external workload metrics and their related indices calculations.<sup>18,20,21</sup> In fact, a study that analyzed match demands of 810 starters and 256 non-starters from the English Premier League revealed that non-starters covered greater high-intensity-running distance than starters, although technical actions did not show any variation.<sup>22</sup> However, a recent systematic review addressed the fact that there is conflicting evidence regarding the high-intensity activities of both starters and non-starters.<sup>23</sup> The authors of the above-mentioned study attributed this conflicting evidence to the between-match variations in high-speed activities.<sup>23</sup> Also, the contextual factors, such as coach encouragement, among others, can influence these movement patterns during match-play.<sup>24</sup>

Also, training workload mediators (e.g. wAW, wCW, and wACWR) and moderators (e.g. weekly wHSRd, wSTD, and wRS) play an important role from an injury prevention perspective.<sup>25,26</sup> Indeed, both training workload mediators and moderators have been related to injury risk. In fact, the avoidance of sudden wAW spikes > 15%, progressively increasing wCW, and maintenance of a balanced wACWR between 0.8 and 1.3 arbitrary units (A.U.) are some of the main suggestions for greater protective effects.<sup>27</sup> Similarly, moderate exposure of approximately 800-m of wHSRd, 300–400-m of wSTD, and greater RS capacity are also related to greater wAW tolerance, and consequently related to lower injury risk.<sup>25,26</sup> As such, examining the profiles of the training workload mediators and



computed for the PreS period. However, the accumulated load was used to calculate the CW and ACWR during the first weeks of in-season.

The criterion for dividing players into the starter and non-starter groups was based on previous studies that used 60 min of play in weekly matches.<sup>18,21</sup> During training weeks with no matches, the division criterion was based on the total training time per week.<sup>18,21</sup> Based on this methodology, the players were divided into 10 players in the starter group and 11 players in the non-starter group.

## External monitoring measures

### Microelectromechanical system

Players were monitored throughout the season using a 15 Hz GPS unit integrating a 100 Hz tri-axial accelerometer, 50 Hz magnetometer, and 16 G tri-axial track impacts GPSports System Pty Ltd (Model: SPI High Performance Unit, Canberra, Australia). Each player used their respective GPS device in all training sessions and in all matches. The validity and reliability of the GPS device was previously confirmed.<sup>30</sup>

### Data collection

Data collection from the GPS unit was performed according to the considerations of previous studies.<sup>18,21,31,32</sup> The variables used from the GPS data for this study included the following: (1) duration in minutes, (2) total distance, (3) high-speed running distance (18–23 km/h<sup>-1</sup>), (4) new player load (calculated by accelerometer data), (5) repeated sprints, and (6) sprint total distance. The GPSports new player load metric calculation replaced the original GPSports NPL and was used as a training load marker, as previously documented.<sup>33</sup>

### Calculation of training workload

In this study, NPL was used as the criterion for the training workload.<sup>18,21</sup> The weekly acute load (wAL) was the accumulated daily loads during 1-week for each GPS metric, while the weekly chronic load (wCW) was calculated as the average accumulated load of the previous 3-weeks, using the uncoupled formula.<sup>34,35</sup> The weekly acute:chronic workload ratio was also calculated using the uncoupled formula<sup>35,37</sup> as shown in equation (1):

$$\text{ACWR}4 = [\text{wAW}4]/(0.333 \times (\text{wAW} 2 + \text{wAW} 3 + \text{wAW} 4)] \quad (1)$$

The wCW and wACWR during the PreS period were not considered for analysis.

## Statistical analysis

The Statistical Package for the Social Sciences (SPSS, version 25.0, IBM SPSS Inc., Chicago, IL, USA) was used for statistical procedures and analyses. Data are presented as mean and standard deviation (SD). Kolmogorov–Smirnov and Levene's tests were executed to check the normality and homogeneity of data, respectively. Then, inferential tests were conducted. Repeated measures analysis of variance (ANOVA) was applied to analyze within-group changes across the different periods of the season in all dependent variables for both starter and non-starter soccer players. Bonferroni post hoc tests were also executed to determine pairwise comparison outcomes. Significant differences were considered for  $p \leq 0.05$ . Partial eta squared ( $\eta_p^2$ ) was calculated as effect size of the repeated measures ANOVA. Thresholds for  $\eta_p^2$  were applied as follows:  $\geq 0.01$ , small effect;  $\geq 0.06$ , medium effect; and  $\geq 0.14$ , large effect. Moreover, Hedge's  $g$  effect size (95% confidence interval) was calculated to determine the magnitude of pairwise comparisons.<sup>36–38</sup> Hopkins' thresholds for Hedge's  $g$  effect size statistics were used<sup>39</sup> as follows:  $\leq 0.2$ , trivial;  $> 0.2$ , small;  $> 0.6$ , moderate;  $> 1.2$ , large;  $> 2.0$ , very large; and  $> 4.0$ , nearly perfect.

## Results

Table 2 shows the within-group comparisons of training workload parameters between the different periods of the season for both starters and non-starters. The outcomes of repeated-measures ANOVA revealed large significant differences between season periods in wAW and wACWR for both starters (wAW:  $p = 0.003$ ,  $\eta_p^2 = 0.541$ ; wACWR:  $p < 0.001$ ,  $\eta_p^2 = 0.964$ ) and non-starters (wAW:  $p < 0.001$ ,  $\eta_p^2 = 0.696$ ; wACWR:  $p < 0.001$ ,  $\eta_p^2 = 0.943$ ). However, wCW outcomes also revealed large meaningful differences in non-starters ( $p = 0.009$ ,  $\eta_p^2 = 0.408$ ), but non-significant in starters ( $p = 0.063$ ,  $\eta_p^2 = 0.264$ ). Specifically, pairwise comparisons are shown in Table 2.

Within-group comparisons of distance and sprint derived-GPS parameters between the different season periods for both starters and non-starters are displayed in Tables 3 and 4. Overall, repeated-measures ANOVA showed large significant differences between season periods for wTD and wSTD for both starters (wTD:  $p < 0.001$ ,  $\eta_p^2 = 0.810$ ; wSTD:  $p = 0.014$ ,  $\eta_p^2 = 0.457$ ) and non-starters (wTD:  $p < 0.001$ ,  $\eta_p^2 = 0.895$ ; wSTD:  $p < 0.001$ ,  $\eta_p^2 = 0.781$ ). There were also differences with large effect between season periods for wRS in non-starters ( $p < 0.001$ ,  $\eta_p^2 = 0.722$ ), but not in starters ( $p = 0.086$ ,  $\eta_p^2 = 0.314$ ). No differences between season periods were found for wHSRd for starters ( $p = 0.677$ ;  $\eta_p^2 = 0.083$ ) or non-starters ( $p = 0.051$ ;  $\eta_p^2 = 0.359$ ). Specifically, pairwise comparisons are displayed in Tables 3 and 4.

**Table 2.** Within-group differences for pairwise comparisons between season periods for wAW, wCW, and wACWR for both starter and non-starter players.

	Period	Mean (SD)	Comparative	Group	p Value	Hedge's g (95% CI)
wAW (AU)	Pre-season	Starters: 701.70 (124.22) Non-starters: 624.61 (199.59)	PreS vs EarS	Starters	0.779	0.74 (−0.17 to 1.64)
				Non-starters	> 0.999	0.38 (−0.47 to 1.22)
	Early-season	Starters: 615.49 (98.95) Non-starters: 559.23 (127.02)	PreS vs MidS	Starters	<b>0.033</b>	1.62 (0.61–2.63)
				Non-starters	<b>0.017</b>	1.15 (0.25–2.05)
			PreS vs EndS	Starters	<b>0.002</b>	1.95 (0.89–3.02)
				Non-starters	< <b>0.001</b>	1.64 (0.67–2.60)
	Mid-season	Starters: 532.67 (67.60) Non-starters: 447.86 (63.90)	EarS vs MidS	Starters	0.440	0.94 (0.01–1.86)
				Non-starters	0.090	1.07 (0.17–1.96)
	End-season	Starters: 492.66 (74.80) Non-starters: 371.68 (65.36)	EarS vs EndS	Starters	0.052	1.34 (0.37–2.31)
				Non-starters	<b>0.001</b>	1.79 (0.80–2.77)
MidS vs EndS			Starters	> 0.999	0.54 (−0.35 to 1.43)	
			Non-starters	0.073	1.13 (0.23–2.03)	
wCW (AU)	Early-season	Starters: 604.18 (91.26) Non-starters: 543.20 (132.46)	EarS vs MidS	Starters	0.746	0.60 (−0.29 to 1.50)
				Non-starters	0.104	0.83 (−0.04 to 1.70)
	Mid-season	Starters: 552.43 (71.50) Non-starters: 448.83 (79.53)	EarS vs EndS	Starters	0.074	1.19 (0.24–2.14)
				Non-starters	<b>0.006</b>	1.39 (0.46–2.32)
	End-season	Starters: 501.84 (72.88) Non-starters: 400.29 (45.87)	MidS vs EndS	Starters	0.343	0.67 (−0.23 to 1.57)
				Non-starters	0.337	0.72 (−0.14 to 1.58)
wACWR (AU)	Early-season	Starters: 1.05 (0.05) Non-starters: 1.12 (0.06)	EarS vs MidS	Starters	> 0.999	0.19 (−0.69 to 1.07)
				Non-starters	> 0.999	−0.15 (−0.98 to 0.69)
	Mid-season	Starters: 1.04 (0.08) Non-starters: 1.14 (0.16)	EarS vs EndS	Starters	> 0.999	0.24 (−0.64 to 1.12)
				Non-starters	<b>0.004</b>	1.63 (0.67–2.60)
	End-season	Starters: 1.04 (0.07) Non-starters: 1.00 (0.08)	MidS vs EndS	Starters	> 0.999	0.02 (−0.85 to 0.90)
				Non-starters	<b>0.044</b>	1.06 (0.17–1.95)

SD: standard deviation; AU: arbitrary units; PreS: preseason period; EarS: early-season period; MidS: mid-season period; EndS: end-season period; wAW: weekly acute workload in AU; wCW: weekly chronic workload in AU; wACWR: weekly acute:chronic workload ratio in AU; p: p-value at alpha level 0.05; Hedge's g (95% CI): Hedge's g effect size magnitude with 95% confidence interval.

Pre-season period was not considered for wCW and wACWR pairwise comparisons. Significant differences ( $p \leq 0.05$ ) are highlighted in bold.

## Discussion

The purposes of this study were to analyze the differences between periods of the season for starters and non-starters separately for (1) wAW, wCW, and wACWR and (2) wTD, wHSRd, wSTD, and wRS. The main finding was the values for all the workload and distance-based variables in the earlier periods of the season were greatest, followed by a linear decrease until the EndS, for both starters and non-starters. Also, non-starters presented greater differences between PreS and EndS for all variables, except for wHSRd, which showed no differences for both groups.

Considering the differences of all workload measures, the starters presented differences only for wAW between PreS and EndS, while non-starters showed differences for wAW and wCW, mainly between early periods to EndS. Also, higher values in the early stages

of the season (PreS and EarS) for both groups were observed. In fact, in the first part of this study previously published for between-group differences, no differences between starters and non-starters were found for wAW, wCW, and wACWR values for the PreS and EarS.<sup>29</sup> The higher values presented for all workloads during the early stages of the season were expected and are in concordance with other research, showing that higher training loads usually occur during the PreS period.<sup>14,19</sup> In the present study, this was reflected by a greater wAW during the PreS and consequently greater wCW during EarS periods, which were then followed by linear decreases throughout the season. Although PreS is a period of greater perceived training loads, which are associated with higher injury risk occurrence, it also seems to protect athletes from injury during the in-season.<sup>40</sup> Furthermore, considering that coaches usually make the majority of substitutions during the

**Table 3.** Within-group differences for pairwise comparisons between season periods for wTD and wHSRd for both starter and non-starter players.

	Period	Mean (SD)	Comparative	Group	<i>p</i> Value	Hedge's <i>g</i> (95% CI)
wTD (m)	Pre-season	Starters: 30840.21 (765.07) Non-starters: 24540.07 (5869.97)	PreS vs EarS	Starters	0.057	1.82 (0.78–2.87)
				Non-starters	<b>0.009</b>	0.84 (−0.03 to 1.71)
	Early-season	Starters: 27721.13 (2187.14) Non-starters: 20731.58 (1955.32)	PreS vs MidS	Starters	< <b>0.001</b>	4.64 (2.96–6.33)
				Non-starters	< <b>0.001</b>	1.59 (0.63–2.55)
	Mid-season	Starters: 24599.78 (1651.14) Non-starters: 17040.86 (2562.86)	PreS vs EndS	Starters	< <b>0.001</b>	4.89 (3.14–6.64)
				Non-starters	< <b>0.001</b>	2.02 (0.99–3.04)
	End-season	Starters: 23860.94 (1777.09) Non-starters: 15457.63 (1739.30)	EarS vs MidS	Starters	< <b>0.001</b>	1.54 (0.54–2.54)
				Non-starters	< <b>0.001</b>	1.56 (0.60–2.51)
	End-season	Starters: 23860.94 (1777.09) Non-starters: 15457.63 (1739.30)	EarS vs EndS	Starters	< <b>0.001</b>	1.86 (0.81–2.90)
				Non-starters	< <b>0.001</b>	2.74 (1.58–3.91)
End-season	Starters: 23860.94 (1777.09) Non-starters: 15457.63 (1739.30)	MidS vs EndS	Starters	0.567	0.41 (−0.47 to 1.30)	
			Non-starters	<b>0.005</b>	0.70 (−0.17 to 1.56)	
wHSRd (m)	Pre-season	Starters: 403.66 (99.83) Non-starters: 230.91 (114.78)	PreS vs EarS	Starters	> 0.999	0.38 (−0.50 to 1.27)
				Non-starters	> 0.999	−0.02 (−0.86 to 0.81)
	Early-season	Starters: 362.87 (103.69) Non-starters: 233.39 (74.44)	PreS vs MidS	Starters	> 0.999	0.40 (−0.48 to 1.29)
				Non-starters	> 0.999	0.32 (−0.52 to 1.17)
	Mid-season	Starters: 369.11 (59.82) Non-starters: 200.91 (51.97)	PreS vs EndS	Starters	> 0.999	0.40 (−0.48 to 1.29)
				Non-starters	0.581	0.53 (−0.32 to 1.38)
	End-season	Starters: 369.11 (59.82) Non-starters: 200.91 (51.97)	EarS vs MidS	Starters	> 0.999	−0.07 (−0.95 to 0.81)
				Non-starters	> 0.999	0.49 (−0.36 to 1.33)
	End-season	Starters: 369.20 (59.21) Non-starters: 182.73 (45.03)	EarS vs EndS	Starters	> 0.999	−0.07 (−0.95 to 0.81)
				Non-starters	0.057	0.79 (−0.08 to 1.66)
End-season	Starters: 369.20 (59.21) Non-starters: 182.73 (45.03)	MidS vs EndS	Starters	> 0.999	0.00 (−0.88 to 0.88)	
			Non-starters	> 0.999	0.36 (−0.48 to 1.20)	

SD: standard deviation; AU: arbitrary units; PreS: pre-season period; EarS: early-season period; MidS: mid-season period; EndS: end-season period; wTD: weekly total distance in meters; wHSRd: weekly high-speed running distance in meters; *p*: *p*-value at alpha level 0.05; Hedge's *g* (95% CI): Hedge's *g* effect size magnitude with 95% confidence interval.

Significant differences ( $p \leq 0.05$ ) are highlighted in bold.

second half of a match between 60 and 85 min,<sup>22,41</sup> without accounting for possible early substitutions due to injuries, non-starters are expected to play only 30 min or less.<sup>22,23</sup> This may be reflected by a diminished wAW and consequently lower wCW for non-starters, compared to starters. In fact, in a study conducted on 14 professional soccer players that aimed to analyze the match physical performance differences between starters and non-starters, it was revealed that starters declared greater perceived exertions than non-starters.<sup>42</sup>

Given the fact that in the present study non-starters presented greater differences in a decreased way between periods of the season for internal load measures, it would be beneficial to ensure compensatory simulated match training sessions. Indeed, the between-group (starters vs non-starters) differences in the previously published first part of this study revealed greater wAW and wCW for starters in relation to non-starters, mainly in MidS (wAW:  $p = 0.008$ ,  $g = 21.24$ ; wCW:  $p = 0.006$ ;  $g = 21.31$ ) and EndS (wAW:  $p = 0.001$ ,  $g = 21.66$ ; wCW:  $p = 0.001$ ;  $g = 21.62$ ), respectively.<sup>29</sup>

Also, only non-starters showed differences for wACWR from EarS to EndS. However, from a practical perspective, differences in wACWR for non-starters do not seem relevant, as this ratio remained in the considered “safe zone” of workloads, not representing an alert.<sup>27</sup>

Regarding the second objective of this study, greater distances were recorded for all variables (Tables 2 and 3) during PreS, followed by linear slight decreases until the EndS for only wTD. Both groups presented differences in wTD and wSTD, while only non-starters presented differences in wRS. Also, both groups presented no differences for wHSRd. In the previously published first part of this study for the between-group analysis, starters presented greater wTD, wSTD, wHSRd, and wRS in all periods of the season ( $p < 0.05$ ;  $g = 21.36$ – $24.95$ ) than non-starters.<sup>29</sup> When considering the values of distance-based metrics, such as wTD, the present results were similar to the study by Clemente et al.<sup>19</sup> in which wTD was greater in PreS than in the first and second halves of the season. The same study also found

**Table 4.** Within-group differences for pairwise comparisons between season periods for wSTD and wRS for both starter and non-starter players.

	Period	Mean (SD)	Comparative	Group	p Value	Hedge's g (95% CI)	
wSTD (m)	Pre-season	Starters: 2574.45 (236.50) Non-starters: 1857.79 (662.27)	PreS vs EarS	Starters	0.221	1.02 (0.09–1.95)	
				Non-starters	> 0.999	0.07 (–0.76 to 0.91)	
	Early-season	Starters: 2320.95 (240.58) Non-starters: 1817.63 (306.64)	PreS vs MidS	Starters	<b>0.019</b>	2.03 (0.95–3.11)	
				Non-starters	<b>0.033</b>	0.77 (–0.10 to 1.63)	
	Mid-season	Starters: 2118.68 (191.80) Non-starters: 1454.07 (276.99)	PreS vs EndS	Starters	<b>0.009</b>	2.65 (1.45–3.85)	
				Non-starters	<b>0.001</b>	1.19 (0.28–2.09)	
	End-season	Starters: 2062.09 (111.75) Non-starters: 1256.87 (189.92)	EarS vs MidS	Starters	0.182	0.89 (–0.03 to 1.81)	
				Non-starters	<b>0.002</b>	1.20 (0.29–2.10)	
	MidS vs EndS			Starters	> 0.999	0.35 (–0.54 to 1.23)	
				Non-starters	<b>0.002</b>	0.80 (–0.07 to 1.67)	
	wRS (number)	Pre-season	Starters: 86.56 (14.45) Non-starters: 64.22 (23.25)	PreS vs EarS	Starters	0.510	0.71 (–0.19 to 1.62)
					Non-starters	0.340	–0.46 (–1.31 to 0.39)
Early-season		Starters: 77.76 (8.47) Non-starters: 73.60 (15.16)	PreS vs MidS	Starters	0.066	1.28 (0.32–2.24)	
				Non-starters	0.938	0.41 (–0.43 to 1.26)	
Mid-season		Starters: 71.09 (7.68) Non-starters: 56.50 (10.28)	PreS vs EndS	Starters	0.067	1.51 (0.51–2.50)	
				Non-starters	0.155	0.79 (–0.08 to 1.65)	
End-season		Starters: 69.13 (6.06) Non-starters: 49.92 (8.49)	EarS vs MidS	Starters	0.711	0.79 (–0.12 to 1.70)	
				Non-starters	<b>0.002</b>	1.27 (0.35–2.19)	
EarS vs EndS				Starters	0.222	1.12 (0.18–2.06)	
				Non-starters	< <b>0.001</b>	1.85 (0.85–2.85)	
MidS vs EndS				Starters	> 0.999	0.27 (–0.61 to 1.15)	
				Non-starters	0.117	0.67 (–0.19 to 1.53)	

SD: standard deviation; AU: arbitrary units; PreS: pre-season period; EarS: early-season period; MidS: mid-season period; EndS: end-season period; wSTD: weekly sprint total distance in meters; wRS: weekly repeat sprint as number; p: p-value at alpha level 0.05; Hedge's g (95% CI): Hedge's g effect size magnitude with 95% confidence interval.

Significant differences ( $p \leq 0.05$ ) are highlighted in bold.

greater values for wHSRd in PreS than in the first and second halves of the season, while in the present study, the wHSRd did not reveal differences between periods of the season, neither for starters nor non-starters. The greatest differences were only observed for wTD for both groups, between the overall periods of the season. The lack of differences in wHSRd between periods for both groups may be a result of the self-imposed higher intensity efforts by non-starters as they have shorter playing time.<sup>42</sup> The HSR is an important moderator of training loads, as this running metric is associated with hamstring strain injuries.<sup>43</sup> Despite sudden increases in wHSRd that are related to increased injury risk, CW higher than ~3000 A.U. and wHSRd higher than ~800 m can have a protective effect against hamstring strain injuries.<sup>44</sup> For these reasons, coaches should be aware of these patterns and manage wHSRd for both starters and non-starters throughout the season, considering a periodized planning with ~3 weeks of HSR overload followed by 1 week of deloading, as it seems to be related to lower risk of injury.<sup>43</sup>

Furthermore, starters and non-starters presented significant differences between all periods for wSTD, except between PreS and EarS. Greater volumes of sprinting during PreS, compared to the final stages of the season period, have been documented.<sup>19</sup> The first weeks of the soccer season are mainly focused on improving physical condition and capacity, which is reflected by the greater training session frequency, and 1–2 weekly preparation matches.<sup>45</sup> In fact, better physical performance is expected to occur after the PreS period as a consequence of the augmented technical, tactical, and physical training during the PreS.<sup>45,46</sup> Thus, it was expected that both starters and non-starters would show higher values of sprint and RS distances during this period.

Moreover, reductions between PreS and EndS periods ( $p < 0.009$ ;  $\eta_p^2 = 2.65$ ) for STD in starters were found in the present study. This finding is similar to findings in previous studies that showed decrements in speed after the pre-season period.<sup>47,48</sup> These decrements may be associated with fatigue levels due to training

and match load accumulation during the in-season period, which can explain the greater difference between PreS to EndS for starters. Although decrements were also observed for wRS from PreS to EndS in both groups, only non-starters revealed differences in wRS between EarS to MidS and EarS to EndS. Other studies revealed that non-starters tend to cover greater match high-intensity running distances than their replaced counterparts, even if they are replaced during the second half.<sup>22,49</sup> On the other hand, it was documented that the greater wHSRd and wSTD of starters are related to match playing time.<sup>50</sup> Despite that, in the present study, non-starters presented lesser wRS than starters in all periods, which may be due to a lack of training adjustments for the players with lower playing times. As RS ability has been argued to be an essential physical performance determinant in soccer, due to the HSR demands interspersed with short recovery periods,<sup>51</sup> it should be of paramount importance for coaches to ensure effective exposure to wSTD and wRS for non-starters. Indeed, it was previously documented that ensuring an exposure to wHSRd (using a GPS speed threshold > 19.8 km/h) of approximately 800 m and wSTD of approximately 350 m can better prepare players to cope with match demands.<sup>44</sup> This is especially important for non-starters or players with less match participation so that they can help the team to perform better without higher risks of injury occurrence.

This study has some limitations. The small sample size is one of the main limitations of the present study. However, this is a common issue of studies analysing full seasons of elite/professional soccer teams. Although this study used an NPL metric as a training load marker that englobes tri-axial accelerometer data,<sup>21</sup> impact and collision metrics were not considered in isolation. Future studies should investigate the seasonal profiling of those metrics, considering full or partial participation in soccer matches and their weekly loads. This would give coaches important insights, as muscle damage and fatigue levels are strongly related to those metrics.<sup>52</sup> The analyzed differences did not consider different player positions. It would be interesting to address positional dependencies in future research.

## Conclusion

Starters presented higher values than non-starters for all workload and distance-based variables between all periods. Both groups revealed higher loads in the early periods of the season, compared to MidS and EndS. Higher match participation seemed to result in higher weekly loads for all variables in relation to partial participation. Despite non-starters seeming to experience greater high-intensity demands during a match than starters, it may not be enough to balance the weekly loads between-groups. As a result, coaches should plan compensatory training sessions and ensure greater

exposure to wSTD and wRS for non-starters. Also, as starters are more exposed to higher workloads for all variables throughout the season, special attention should be given to fatigue monitoring.


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## Supplemental material

Supplemental material for this article is available online.

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