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Relations of the Weekly External Training Load Indicators and Running Performances in Professional Soccer Matches

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Abstract

The aim of this study was (i) to examine associations between training load during the week and match outcomes; (ii) to evidence position-specific differences between playing positions of training load and match running performances in top-level soccer/football. Training load and match running performances were evaluated through external load parameters: total-distance-covered, distance covered by walking, jogging, running, high-intensity-running (high-speed-running + sprinting); the number of accelerations, high-intensity-accelerations, decelerations, and high-intensity- decelerations. All data were obtained via the Global Positioning System from twelve matches of the highest-level Croatian soccer competition and from training sessions in the preceding weeks. The players (age: 23.57±2.84 years) were divided into five playing positions: central defenders (n=18), full-backs (n=20), central midfielders (n=26), wing midfielders (n=5) and forwards (n=9). Significant ANOVA differences ($p<0.05$) were found in all external match load variables, while in weekly training sessions only in high-intensity-running, high-intensity-accelerations, and high-intensity- decelerations distinguished players across their playing positions. Inverse correlation for most of the external load parameters and positive correlation for the number of training sessions with match outcome was evidenced. Chances of positive match outcome were greater in weeks when the team participated in fewer training sessions and consequently had lower values of external training load.

Keywords: *football, training load, game load, relationships, conditioning, performance analysis*

Introduction

Soccer (football) is characterized by numerous dynamic activities' cyclic and acyclic movements (Gardasevic & Bjelica, 2019). The physical demands of elite soccer matches have increased substantially over the previous decade (Bradley et al., 2016). With regards to the different tactical roles, these demands vary according to the different playing positions (Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009; Mallo, Mena, Nevado, & Paredes, 2015; Modric, Versic, Sekulic, & Liposek, 2019; Mouloud, 2019). Previous studies have provided detailed information about the position-specific running performances (Sarmento et al., 2014). In brief, it was highlighted that midfielders cover the highest total distance and players that play by the sides of the field (e.g., full-backs and wing midfielders) cover the greatest distances in high-intensity running (Di Salvo et al., 2007; Modric et al., 2019).

With the increased physical demands of soccer matches, optimal physical preparation of players became an indispensable part of professional soccer (Andrzejewski, Konefał, Chmura, Kowalczuk, & Chmura, 2016), while the monitoring of the training load turned out to be a key factor for accurate control of the training process (Rebelo et al., 2012). Specifically, an accurate evaluation of training load is paramount for the planning and periodization of training, especially with regard to the prevention of undertraining or overtraining, and ensuring that athletes are in an optimal condition for competition (Rebelo et al., 2012).

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Training load can be differentiated into external and internal loads. The external load can be derived from measurements of a player's movement on the pitch, and the internal load is related to the physiological and psychological stresses imposed on the player's body (Jaspers, Brink, Probst, Frencken, & Helsen, 2017). Typically, measures of internal training load are heart rate-based training impulse (TRIMP) and the session rate of perceived exertion (s-RPE) (Wallace, Slattery, & Coutts, 2014), while external training load is mostly evaluated with measures obtained from GPS or video-based technologies (i.e., total distance covered, different speed zone distance covered, accelerations and decelerations) (Scott, Lockie, Knight, Clark, & de Jonge, 2013).

Previous studies have described the in-season training periodization practices of elite soccer teams in detail. Briefly, Malone et al. (2015) and Stevens, de Ruiter, Twisk, Savelsbergh, and Beek (2017) reported lower training loads when training sessions approached match day. In a recent study, Oliveira et al. (2019) evidenced in-season external training load of UEFA Champions League team and indicated that total distance tended to decrease during the in-season (from 5589 m to 4545 m) (Oliveira et al., 2019). Akenhead, Harley, and Tweddle (2016) observed position-specific external training load of an English Premier League soccer team during training and found that some acceleration variables successfully differentiated playing positions with midfield players covering more distance within the total, low, and moderate acceleration thresholds than central defenders (Akenhead, Harley, & Tweddle, 2016). Clemente et al. (2019) reported that weeks with five training sessions had statistically more significant values for all external load ratios than weeks with three or four sessions.

The final achievement of the soccer game is assessed by match outcome (winning, losing or drawing). Therefore, it is not surprising that authors often search for the parameters that affect match outcome (Oberstone, 2009; Tenga & Sigmundstad, 2011). Several attempts have been made to determine performance indicators that may distinguish winning from losing teams (Oberstone, 2009; Tenga & Sigmundstad, 2011). Consequently, the essential aspects of final performance and achievement were technical indicators (Rampinini, Impellizzeri, Castagna, Coutts, & Wisløff, 2009), tactical- (Taylor, Mellalieu, & James, 2005), physical indicators (Gregson, Drust, Atkinson, & Salvo, 2010), and situation variables (Taylor, Mellalieu, James, & Barter, 2010). Although these studies provided a great deal of valuable information, there is an evident lack of studies that examined the training load parameters as factors of possible influence on match outcomes.

While there is a growing interest for the analysis of how running match performances (i.e., external match load) affect match outcome, to the best of our knowledge, there is no study that has explored the association between external training load from weekly sessions and match outcomes in soccer. Interestingly, authors from other sports (e.g., ice hockey and Australian soccer) have focused on this issue and reported valuable results for their sports (Douglas et al., 2019; Sullivan et al., 2014).

Therefore, the main objective of this study was to examine possible associations between external training load during the week and the match outcomes. Additionally, we examined position-specific training loads, game loads, and training/match ratio for studied soccer players. Altogether, these findings will provide better insight and understanding of the weekly external training sessions' load effects on success in soccer. Consequently, it could positively affect a team's possibility of winning the matches.

Methods

Participants and design

In this research, 77 training running performances were analysed as well as match performances of the same players at the end of the following week. All data were collected during 12 matches of the 2019/2020 season and during training sessions. In the observed period, the team played 7 home and 5 guest matches, with 8 wins, 2 draws, and 2 losses. Players (age: 23.57±2.84 years; body height: 181.9±5.17 cm; body mass: 78.36±4.18 kg) were divided into five different groups depending on playing positions: central defenders (n=18), full-backs (n=20), central midfielders (n=26), wide midfielders (n=5), and forwards (n=9); only players that played the whole game and participated on all training sessions in the week before each match were included in the study. This study was approved by the Ethics Board.

Procedures

The variables observed in this study were running parameters obtained during (i) game and (ii) training over the preceding week, playing position (central defenders, full-backs, central midfielders, wide midfielders, forwards), number of training session performed each week, home/guest match, and final match outcome (win, draw, lost)

Running performances observed in the study were: total distance covered (m); distance in five speed categories (walking (<7.1 km/h), jogging (7.2-14.3 km/h), running (14.4–19.7 km/h), high speed running (19.8–25.1 km/h), and sprinting (>25.2 km/h)); total accelerations (>0.5 m/s^2); high-intensity accelerations (>3 m/s^2); total decelerations (< (-) 0.5 m/s^2) and high-intensity decelerations (< (-) 3 m/s^2). For collecting data, GPS technology (Catapult S5 and X4 devices, Melbourne, Australia) with a sampling frequency of 10 Hz was used. The reliability and validity of the equipment had previously been confirmed in studies (Castellano, Blanco-Villaseñor, & Alvarez, 2011; Johnston, Watsford, Pine, & Spurrs, 2014).

Statistics

The normality of the distributions was checked with a Kolmogorov-Smirnov test, and data are presented as the means ± standard deviations. Differences between playing positions in running variables were analysed using a one-way analysis of variance (ANOVA) with Scheffe posthoc test. The ANOVA calculations were done separately for game-load and training-load variables. Associations between running parameters obtained at training and games were identified with Pearson's coefficient of correlation. Logistic regression for binary outcome was calculated in order to identify the association between running performances achieved at training during the preceding week and match outcome. The match outcome was binarized, and a won match was considered to be a "positive outcome" (coded as "2"), while the remaining two outcomes (loss and draw) were considered to be "negative outcomes" (coded as "1"). The logistic regression was controlled for covariate "home/guest match", since

it was expected that there is a strong influence of this variable on match outcome, with a lower likelihood for a positive outcome for guest matches. In addition to running performances, the correlation was calculated between the number of training sessions in a week and match outcome (criterion). The Odds Ratio (OR), and 95% Confidence Interval (95%CI) were reported for each predictor (running performance). For all analyses, Statistica 13.0 (TIBCO Software Inc, USA) was used, and a p-level of 95% was applied.

Results

Significant ANOVA differences across playing positions ($p<0.05$) were found in all external match load variables. The greatest total distance (10,944 m) covered by central midfielders was significantly higher compared to almost all playing positions (e.g., when compared to central defenders, full-backs and forwards). The forwards covered the greatest distance in high-intensity running (894 m), while central defenders high-intensity distance covered (411 m) was significantly lower compared to all playing positions. The central midfielders carried out the highest number of accelerations and decelerations, while forwards carried out the highest number of high-intensity accelerations and decelerations (Table 1).

Table 1. Comparison of game running performance across playing positions

	Central defenders	Full backs	Central midfielders	Wide midfielders	Forwards	F-test (p)
	M±SD	M±SD	M±SD	M±SD	M±SD	
Total distance (m)	8880.2±512.3	9712.9±578.2	10944.6±615.9	10451.8±860.4	9625.9±471.4	36.59 (0.01)*
Low-intensity (walking + jogging) (m)	7539.0±417.5	7842.7±452.8	8727.7±535.4	8300.3±490.3	7495.6±348.3	23.50 (0.01)*
Running (m)	929.7±135.5	1150.1±128.5	1576.2±279.9	1328.3±230.7	1235.0±98.2	30.81 (0.01)*
High-intensity (high speed running + sprinting) (m)	411.3±111.8	709.4±123.5	644.2±184.2	823.3±284.3	894.0±195.4	16.60 (0.01)*
Accelerations (count)	395.2±58.8	387.7±89.9	477.3±53.5	434.5±59.7	393.0±39	7.30 (0.01)*
Decelerations (count)	396.0±64.7	401.8±40.7	471.7±48.3	429.5±71.7	398.2±35	8.63 (0.01)*
High-intensity accelerations (count)	12.7±3.3	11.9±4.2	10.8±4.8	10.3±3.3	30.0±8.3	29.24 (0.01)*
High-intensity decelerations (count)	27.4±6.7	29.9±7.9	34.2±10.6	36.5±14.2	50.9±5.2	11.93 (0.01)*

Legend: M – Mean; SD - Standard deviation; * - significant difference

The greatest weekly total distance was covered by forwards (19,829 m) and central midfielders (19,095 m), but no significant differences across playing positions were found. The highest amount of high-intensity running was performed by full-backs players (742 m), while the lowest was performed by central midfielders (428 m), with significant posthoc difference between full-backs and central midfielders. The forwards and central defenders carried out the highest number of total accelerations/decelerations and high-intensity accelerations/decelerations (Table 2).

Table 2. Comparison of running performance in weekly training sessions across playing positions

	Central defenders	Full backs	Central midfielders	Wide midfielders	Forwards	F-test (p)
	M±SD	M±SD	M±SD	M±SD	M±SD	
Total distance (m)	18070.4±4161.7	17531.7±5376.4	19095.9±5523	18880.0±5391	19829.0±6294.8	0.43(0.79)
Low-intensity (walking + jogging) (m)	16071.4±3750.9	15271.3±4893.4	16999.3±4783.6	16589.8±4514.9	17348.4±5562.4	0.51(0.73)
Running (m)	1468.9±336.1	1517.4±423.4	1681.3±841.1	1609.8±627.5	1826.1±651.3	0.70(0.59)
High-intensity (high speed running + sprinting) (m)	529.5±204.4	742.9±253.9	428.9±278.6	679.8±390.8	654.3±227	4.76(0.01)*
Accelerations (count)	802.4±214.5	707.6±235.8	794.0±320.4	735.0±342.5	895.6±324.5	0.79(0.53)
Decelerations (count)	799.7±207.5	697.1±235.1	804.8±287.6	801.3±242.7	887.2±324.5	0.98(0.43)
High-intensity accelerations (count)	32.5±13.1	25.3±9.2	15.8±7.1	24.3±12.2	31.6±12.3	8.65(0.01)*
High-intensity decelerations (count)	63.1±25.8	41.1±11.6	35.1±21.5	35.0±17.5	66.7±27.2	7.30(0.01)*

The highest training/match ratio was evidenced for the total number of accelerations (2.09), distance covered at low speeds (7.1-14.3 km/h) (2.04) and high-intensity accelerations (2.01) total number decelerations (1.87), and for total distance covered (1.87) (Figure 1). The training/match ratio for distance covered while running at medium speed (14.4–19.7 km/h) and high speeds (19.8+ km/h) was 1.31 and 0.92, respectively (Figure 1).

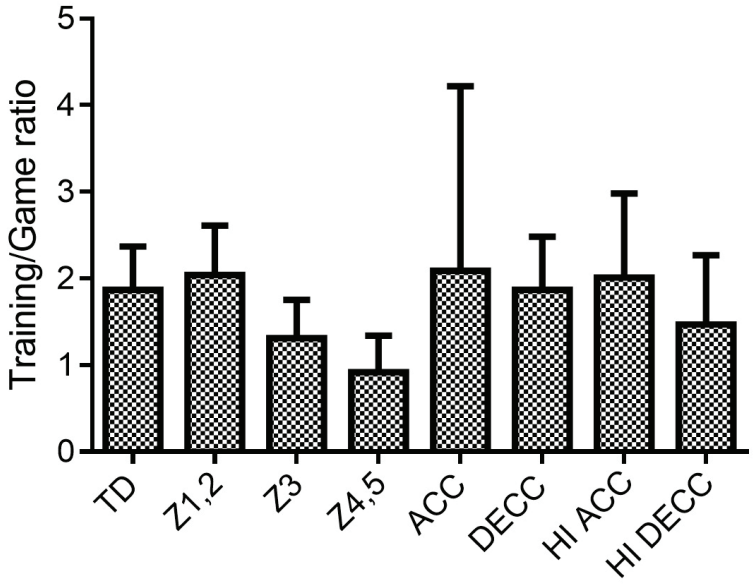

FIGURE 1. Training/match running performance ratio

Legend: TD – total distance; Z1,2 – low intensity running; Z3 – running; Z4,5 – high intensity running; ACC – acceleration; DECC – deceleration; HI ACC – high intensity accelerations; HI DECC – high intensity decelerations

The total distance covered (r=0.25), distance covered in running zone (r=0.39), high-intensity distance covered (r=0.48), high-intensity number of accelerations (r=0.43) and decelerations (r=0.39) from weekly training sessions were significantly correlated with values of associated match variables (Table 3).

Table 3. Pearson's correlation coefficients between running performance and weekly training performance of the corresponding variables

	Total distance (G)	Low-intensity running (G)	Running (G)	High-speed running (G)	Sprint (G)	High-intensity running (G)	Total accelerations (G)	Total decelerations (G)	High intensity-accelerations (G)	High-intensity decelerations (G)
Total distance (W)	0.25*	0.16	0.25*	0.29*	0.02	0.22	0.08	0.13	0.29*	0.30*
Low intensity (walking + jogging) (W)	0.25*	0.19	0.23*	0.25*	-0.02	0.17	0.09	0.14	0.27*	0.26*
Running (W)	0.27*	0.09	0.39*	0.45*	0.11	0.38*	0.15	0.17	0.35*	0.45*
High-intensity (high speed running + sprinting) (W)	-0.07	-0.26*	0.01	0.37*	0.51*	0.48*	-0.34*	-0.26*	0.21	0.25*
Total accelerations (W)	0.18	0.07	0.25*	0.28*	0.02	0.21	0.13	0.16	0.37*	0.39*
Total decelerations (W)	0.22	0.12	0.27*	0.28*	-0.00	0.20	0.15	0.21	0.36*	0.38*
High-intensity accelerations (W)	-0.41*	-0.48*	-0.30*	-0.02	0.33*	0.12	-0.28*	-0.30*	0.43*	0.23*
High-intensity decelerations (W)	-0.27*	-0.37*	-0.11	0.08	0.18	0.13	-0.18	-0.22	0.50*	0.39*

Legend: * - significant correlation

Table 4 presents the results of logistic regression for the binary outcome measure: match outcome. In general, most of the running performances in training were negatively related to the match outcome. Specifically, there is a lower likelihood for positive match outcome (e.g., winning the game), if players in weekly training sessions achieved higher: total distance covered (OR: 0.98; 95%CI: 0.98-0.99), low intensity (walking + jogging) distance covered (OR: 0.99, 95%CI: 0.97-0.99), running zone distance covered (OR: 0.99; 95%CI: 0.98-0.99), Z4W (OR: 0.97; 95%CI: 0.96-0.99), high-intensity (high speed running + sprinting) distance covered (OR: 0.98; 95%CI: 0.97-0.99), total number of accelerations (OR: 0.99; 95%CI: 0.98-0.99), total number of decelerations (OR: 0.98; 95%CI: 0.96-0.99), more high-intensity accelerations (OR: 0.96; 95%CI: 0.95-0.99), and more high-intensity decelerations (OR: 0.98; 95%CI: 0.97-0.99). To summarize, such associations were all generated by higher numbers of training sessions in weeks when the observed team played a game away from home (OR: 0.14, 95%CI: 0.05-0.35)

Table 4. Logistic regressions between running performance during week and number of training sessions with match outcome

	OR	95%CI
Total distance	0.98	0.98-0.99
Low intensity (walking + jogging)	0.99	0.98-0.99
Running	0.99	0.98-0.99
High intensity (high speed running + sprinting)	0.98	0.97-0.99
Total number of accelerations	0.99	0.98-0.99
Total number of decelerations	0.98	0.96.0.99
High-intensity accelerations	0.96	0.95-0.99
High-intensity decelerations	0.98	0.97-0.99
Training sessions per week	0.14	0.05-0.35

Discussion

There are several significant findings of this study, which will be discussed in the following. First, playing positions differed considerably in specific running performances during training and matches. Next, the results indicated significant correlations between corresponding running performances obtained at training and match. Finally, the training load was significantly associated with the match outcome.

Differences among playing positions in running performances

Our results evidenced significant differences between playing positions for total distance covered in soccer matches. These findings are in accordance with the results of previous studies in which authors reported that distance covered during the match varies considering the position-specific tactical roles (Di Salvo et al., 2007; Modric et al., 2019). In detail, while central defenders covered the lowest total distance (8880 m in average), central midfielders total distance covered (10,944m in average) was statistically greater compared to central defenders, full-backs and forwards ($p<0.05$). Similar results are discussed in previous studies in which it was reported that central midfielders usually cover significantly more distance than players in all other playing positions due to their tactical roles (Di Salvo et al., 2007; Modric et al., 2019).

It has already been noted that high-intensity distance covered (above speeds of 20 km/h) in matches is one of the most important elements in successful soccer performance (Di Salvo et al., 2009). Specifically, external players (wide midfielders and full-backs) and front players (forwards) cover the greatest amount of high-intensity distance (Di Salvo et al., 2007; Mallo et al., 2015). Our results indicated that central defenders high-intensity distance covered is statistically lower when compared to all other playing positions ($p<0.05$), while the greatest amount of high-intensity distance in matches was covered by forwards (894 m in average), followed by wide midfielders and full-backs (823 m and 709 m, respectively). Therefore, we may say that our findings are in accordance with previous studies when authors reported similar results for Italian Serie A, Spanish La Liga, and English Premier League (Di Salvo et al., 2007; Di Salvo et al., 2009; Mallo et al., 2015).

The central midfielders have the highest numbers of accelerations and decelerations in the soccer matches (on average 477 and 471, respectively), while forwards have the highest number of high-intensity accelerations and decelerations (in average 30 and 50, respectively). In general, it is difficult to compare our acceleration data with the literature, since there is currently little consensus regarding the use of acceleration thresholds in team sports (Johnston et al., 2014). Moreover, a comparison between acceleration variables measured with different tracking systems (and system versions) would also be difficult (Buchheit et al., 2014).

Although we did not find evidence of significant differences between playing positions, forwards and central midfielders tend to have the highest average weekly total distance (19,829 m and 19,095 m in average, respectively), while full-backs have the lowest (17,531 m in average). The greatest weekly high-intensity distance covered by full-backs (742 m on average) was higher compared to central midfielders, which covered the lowest distance at high speeds through weekly training sessions. Accordingly, it seems that full-backs weekly training drills contain more high-intensity running, while conversely, central midfielders training sessions tend to stimuli greater distance covered without many high-intensity efforts. Furthermore, our results evidenced that central midfielders has the lowest number of high-intensity accelerations (n=15) and decelerations (n=35). As already reported that central midfielders soccer success is more influenced by soccer variables (Modric et al., 2019), it seems that central midfielders training sessions are generally more focused on soccer skills than on running performances.

Training/match ratio

Compared to running performances from the matches, the average total distance from weekly training sessions was

higher by 1.74 times for central midfielders, 1.81 times for wide midfielders, 1.80 for full-backs, 2.04 times for central defenders and 2.05 for forwards. Weekly high-intensity distance covered for full-backs and central defenders was higher (1.05 and 1.30 times, respectively), while for central midfielders, wide midfielders and forwards it was lower (0.63, 0.81, and 0.77, respectively) compared to match values. Acceleration/deceleration load were higher in weekly training sessions compared to the match values. Specifically, the training/match ratio was 2.09 for the total number of accelerations, 1.87 for the total number of decelerations, 2.01 for of high-intensity accelerations and 1.47 for of high-intensity decelerations. This suggests that, through weekly training sessions, the total distance covered and accelerations/decelerations were more emphasized than the high-intensity distance covered. Similar findings were previously discussed in the recent study of Clemente et al. (2019), in which it was presented that "specific variables (e.g. high-speed running distance and sprinting distance) were associated with substantially lower ratios than other variables".

Correlates of match outcome

A strong correlation between the weekly number of training sessions and match outcomes indicated a higher possibility for winning the matches when preceding weeks had lower numbers of training sessions. Furthermore, our results evidenced an inverse association of almost all running performances in weekly training sessions with match outcomes. These findings emphasize that external weekly load values were lower when the team won in subsequent matches. Since it previously was highlighted that the higher weekly number of training sessions provoke a higher weekly external training load (Clemente et al., 2019), a team's positive achievement would be greater in weeks with lower numbers of training sessions and lower values of external training load.

Typical training sessions in weeks with short time until the next games (i.e., weeks with lower numbers of training sessions) are more focused on the recovery and development of soccer skills (e.g., technical and tactical skills) than on strength and conditioning (i.e., adaptation of conditioning abilities cannot be optimal if there is a short period between matches). Consequently, in such weeks the players experienced less external training load, which possibly resulted in better recovery and superior overall fitness status in subsequent matches. Altogether, it allowed players to execute technical and tactical requirements during game situations at a higher level (Borges et al., 2017). Collectively, it logically could result even in better overall achievement and, finally, positive results.

Supportively, previously it was highlighted that soccer players' work rate was lower when winning than losing a match (Castellano et al., 2011). Also, low-ranked teams have greater high-intensity distance covered compared to top-ranked teams (Di Salvo et al., 2009; Rampinini et al., 2009). Considering the results of our study in which we evidenced correlation for almost all running parameters (e.g., total distance covered, high-intensity distance covered, distance covered in the zone of running, number of high-intensity accelerations and decelerations) obtained at training and matches, it seems that external load in matches was affected with external load from training sessions. In other words, if players perform lower external load values in training, lower values of associated external load variables will occur in matches. In accordance with previously cited studies, this could imply that positive results were more affected with technical and tactical skills than with running performances from both training sessions and matches.

Strengths and limitations

This study was based on results obtained from a team in Croatian competition (top-level competition in the country); therefore, results may be generalized to similar qualitative ranks. Also, we did not present any specific data about physical conditioning status, which will allow more detailed discussion. Finally, in this study, we included only those players who participated in all matches and all training sessions; this was necessary due to methodological reasons. Meanwhile, this is one of the first studies where training running performances were simultaneously correlated with: (i) match running performances, and (ii) match outcome. Also, the level of players observed is a significant strength of the investigation. Finally, throughout the study, the same team of professionals (coaches, physicians) managed the observed team, which consequently reduced the possibility that factors other than those observed influenced the results of the study.

The results of this study confirmed that most of the variables of external match load in soccer vary according to the different playing positions. Through weekly training sessions, variables that determine intensity (e.g., high-intensity distance covered (+19.8 km/h), and the number of high-intensity accelerations/decelerations) distinguished players between their playing positions, while no differences were found for volume variables (e.g. total distance covered and the total number of accelerations and decelerations), low-intensity variables (e.g., walking + jogging) and moderate-intensity variables (e.g., distance covered in the zone of running).

Since training/match ratios were higher for total distance covered, distance covered in low speeds, the number of total accelerations/decelerations and the number of high-intensity accelerations, it seems that these variables were more stimulated through training sessions than distance covered at moderate (14.4–19.7 km/h) and high speeds (+20 km/h).

Positive correlations between some external training and match load variables highlighted that if a team performs higher values of total distance covered, distance covered in the running zone, high-intensity distance covered, high-intensity number of accelerations and decelerations in weekly training sessions, higher values of same variables will occur in subsequent matches.

Finally, correlations between the weekly number of training sessions and weekly running performances with match outcome demonstrated that the chances of positive achievement at the game were greater in weeks when the team participated in fewer training sessions and consequently had lower values of external training load.

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Conflict of Interest
The authors declare the absence of conflict of interest.

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