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# Comparison of GPS derived variables based on home versus away matches in the Asian professional soccer team

**Hadi Nobari[1,2,3,4], Maryam Fani[1], Elena Mainer-Pardos[5] and Rafael Oliveira[6,7,8]**

**Abstract**

Professional soccer with high training loads is defined with weekly competition. The purpose of this study was to compare external training load data of GPS derived variables that preceded a home versus away match. Twenty-two weeks of a national league meet schedule were analyzed, which included 11 home and 11 away matches. Twelve professional soccer players (age, 28.6 ± 2.7 years; height, 182.1 ± 8.6 cm; BMI, 22.6 ± 0.7 kg/m$^2$) participated in this study. All matches were monitored using GPSPORTS systems Pty Ltd. The following variables were selected: total duration of the matches and training sessions, high-speed running distance (18–23 km h$^{-1}$), sprint distance (> 23 km h$^{-1}$), maximal speed, body load, metabolic power, accelerations Zone1 (< 2 m s$^{-2}$) (AccZ1), accelerations Zone2 (2 –4 m s$^{-2}$) (AccZ2), accelerations Zone3 (> 4 m s$^{-2}$) (AccZ3), decelerations Zone1 (< −2 m s$^{-2}$) (DecZ1), decelerations Zone2 (−2 to −4 m s$^{-2}$) (DecZ2) and decelerations Zone3 (> −4 m s$^{-2}$) (DecZ3). The results indicated that metabolic power showed higher values at home than away matches [$p$ = 0.047, ES = 0.53, (−0.28, 1.34)]. Furthermore, there was a higher value in accumulated external training load that preceded away matches for high-speed running and lower value [$p$ < 0.001, ES = −0.95 (−1.79, −0.10)] for DecZ1 than home matches. In conclusion, external load variables had a higher value in home matches. However, the results showed that high-speed running was higher in away matches, which could be the discretion of the coaches to prepare players for different conditions on the opponent's field.

**Keywords**

Asian professional league, external load, football, match load, match location, performance, sports technology, training load, sprinting, Persian Gulf Premier League

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## Introduction

Interest in the quantification of training/match loads has increased over the past decade. Load quantification can be a crucial process for adjusting the training stimuli provided to the players according to the conditions of the match. It allows coaches and sports scientists to collect more comprehensive performance data, identify players' training and competition needs, and incorporate them into their training program.[1,2] Soccer is a well-known group activity with highly demanding movement that requires significant effort, combined with a long-term training program. Hence, high practical preparation levels are expected to help soccer players achieve specific training adaptations.[3] Therefore, monitoring the training load is very important to improve performance and advance the team's purposes.

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Monitoring the athlete's internal and external training load can aid in determining the proper stimulus, and consequently, the intensity and volume.[4] Internal load reflects biological responses to training stimuli, as well as the extent of work performed by a player within training sessions and competitions that reflects the external load. Many studies have reported that both internal and external monitoring are performed on many sports teams, especially in soccer.[5]

Playing soccer at a high level requires intensive training to develop and improve the fitness of the players. In addition, high-intensity activities such as sprinting, acceleration, or deceleration are often required during the match. Those activities are related to movements such as ball contests, offensive or defensive acts, and goal-scoring that affect the outcome of the matches.[6] Acceleration and deceleration are two characteristics of external load that are very important for measuring player performance.[2,7,8] The capacity to produce high speed in a short period of time is defined as acceleration, while deceleration is the ability to reduce from high speed to a lower speed.[1] During a match, accelerations represents 7%–10% and decelerations 5%–7% of the players' general load in all playing positions.[9] If the two-halves of the match play are compared, the frequency of high- and very high-intensity accelerations and decelerations decreases from the first to the second half.[10]

Metabolic power is another external load variable.[2] According to earlier research measurements of metabolic need, by assessing body temperature,[11,12] it has been reported that the average load of metabolic power in a soccer player is 70% of the maximum oxygen consumption ($VO_{2max}$). Metabolic power has been presented as a tool that shows the evolution of energy demands as they relate to movements with variable speed, especially in team sports.[13,14] The most accurate way to measure the average metabolic power is to calculate the amount of energy expended by acceleration and deceleration, the data of which is obtained via GPS. Acceleration and deceleration seem to be the main factors determining the cost of energy in a soccer game.[13] During high-intensity levels of a match, the metabolic load is imposed on players. Metabolic power measures an athlete's energy expenditure, so it can be a suitable indicator of the average work intensity.[3]

Newly derived variables, such as body load (BL), have been proposed to study directional changes along all axes, and they can provide useful information for understanding the external workload of training sessions and competitions. The external workload measure furnished by the new BL (NBL) is obtained by calculating the sum of the accelerations in the three movement axis, although some differences regarding this calculation are significant in research literature.[5,15] Differences in constant-velocity motions with variable-velocity motions, such as acceleration, cause differences in the energy cost and demand which consequently increases the external load. Therefore, it is important to monitor an athlete continuously.[5] Despite a lot of research around the world, there is no suitable criterion for measuring the performance of elite soccer players, however, the total distance covered, the high-speed running distance and the accelerations and decelerations seem to be useful metrics. For example, it has been shown that 8% of the total distance covered in a soccer match is related to high speed-running distance, and may be used as an appropriate standard to measure player's performance.[1] High speed-running distance can vary in different players depending on physical performance, tactical and technical roles. This criterion is for the whole team and can be different between games and training sessions.[1]

Moreover, as soccer is dominated by strategic factors, it is reasonable to suggest that situational variables may influence the teams' and players' activities. Empirical evidence suggests that the situational variables such as match location (i.e. playing at home or away), match status (i.e. whether the team was winning, losing or drawing), the quality of the opposition (strong or weak), match result (final score), and parts of the match (first and second halves) are the most important factors for soccer performances.[16] In this sense, match location has been known as one of the most necessary situational variables that dictate possession patterns. While playing a home match, athletes show better interaction with team possession than when playing an away match. In addition, studies have shown that some characteristics, such as stress and sleep, are affected by the location of the match.[17] But the point is that some situational variables, such as the location of the match, may affect the performance and therefore the external load on the player. As reported in a study from 2010, home teams covered a greater distance than visiting teams at low intensity.[16] However, previous research[16,18] used small samples to influence situational variables on external load, and the precise causes, these factors as well as their simple or interactive effects on performance are still not clear.

Furthermore, there are few studies that consider match location regarding training load. However, Abbott et al.[18] and Brito et al.[19] only analyzed subjective variables. Oliveira et al.[17] seems to be the first study that analyzed internal and external training load variables. On one hand, they found that when an away match comes close (compared to a home match), on match-day minus 5 (MD-5), the total distance and high-speed running distance showed higher values, while MD-4 showed higher values for all external variables, MD-3 showed higher values for total distance and average speed. On the other hand, when a home match comes close (compared to an away match), MD-1 showed higher values of total distance, and MD + 1 showed higher values for total distance and high-speed running distance. However, the previous study did not present accelerometry based variables, weekly accumulated data and match data which could clarify the results. Thus, considering the effect of match location on performance and external training load of players, the main purpose of this study was to compare accumulated data that preceded a home versus away match, and also home versus away matches data of GPS derived variables.

## Materials and methods

### Experimental approach to the problem

This study included an analysis of accumulated external training load data derived from GPS variables that preceded home and away matches,[17] as well as the matches from a professional soccer team of the Persian Gulf Premier League. To accomplish the study aims, data from 22 matches of the national league were analyzed (11 home and 11 away matches). Only weeks with one match were included in the analysis. All data was collected during a season of the country's Premier League, which is the highest level of soccer in Iran. During each session (training and matches), players used a GPSPORTS systems Pty Ltd (Model: SPI High-Performance Unit, HPU; Australia).

### Participants

Twelve professional soccer players (age, $28.6 \pm 2.7$ years; height, $182.1 \pm 8.6$ cm; BMI, $22.6 \pm 0.7$ kg/m$^2$), who had at least 8 years of training experience participated in this study. The inclusion criterion required that players must participate in at least three training sessions each week. Also, the players had to participate in three consecutive full matches. The exclusion criteria included prolonged injury or a lack of participation in training for at least two consecutive weeks, goalkeepers were excluded due to differences in workload during training and matches compared with field players.

The experimental approach and study design were presented to the players, then written consent was obtained from all players. The study followed the ethical guidelines of the Helsinki Declaration for the study in Humans, and it was approved by the Ethics Committee of the University of Mohaghegh Ardabili.

### Monitoring external workload

During the season, all matches and workouts were monitored using model SPI HPU GPS-based tracking systems for professional athletes, which offer 15 Hz position GPS and data source BL used a triaxial accelerometer. According to a previous study, this device has a high validity and reliability.[20] This unit was accurate for measuring high-sprinting velocities (coefficient of variation = 0.90%). There were no reported adverse weather conditions to affect data collection. Prior to the start of the matches, belts containing the GPS units were placed on the players' shoulder and chest. After each cool down session at the end of the training, the belts were collected from the players. All belts were checked by the team's GPS manager and then entered into the dock system to download the information, which was then stored on a computer with the Team AMS software. The data from each session was automatically deleted from the belt memory after download. Prior to the next session, the belts were placed in an electric charge station. The SPI IQ Absolutes were adjusted for GPS default zone throughout the season. Also, the personal characteristics, height and weight of each player, were entered in the software and each player's name was registered in a belt assigned to that specific athlete until the end of the season. The following variables were then selected: total duration (TD) of training session, total distance, high-speed running distance (18–23 $\mathrm{km\,h^{-1}}$), sprint distance ($> 23\,\mathrm{km\,h^{-1}}$), maximal speed, AccZ1 ($< 2\,\mathrm{m\,s^{-2}}$), AccZ2 (2 –4 $\mathrm{m\,s^{-2}}$), AccZ3 ($> 4\,\mathrm{m\,s^{-2}}$), DecZ1 ($< -2\,\mathrm{m\,s^{-2}}$), DecZ2 ($-2$ to $-4\ \mathrm{m\,s^{-2}}$), DecZ3 ($> -4\,\mathrm{m\,s^{-2}}$),[3] BL and metabolic power GPS-derived. According to the GPS manufacturer instructions, metabolic power calculation was based on previous research that also showed a strong relationship with running distances.[13]

### Statistical analysis

Data were analyzed using SPSS version 22.0 (SPSS Inc., Chicago, IL) for Windows statistical software package. Initially, descriptive statistics were used to describe and characterize the sample through mean, standard deviation (SD) and 95% confidence intervals (CI, 95%). Shapiro-Wilk and Levene's tests were used to ensure normality and homoscedasticity, respectively. T-tests with CI 95% were used to compare data from external training load data that preceded home versus away matches, and also data from home versus away matches, once variables obtained normal distribution. The $\alpha$ level was set at $p \leqslant 0.05$ for statistical significance.

The percent coefficient of variation (%) was used to characterize the degree of variability of the data. The Hedges' g effect-size (ES) statistic was calculated and expressed with CI, 95% to determine the magnitude of effects, by standardizing the coefficients according to the appropriate between-subjects SD, and was assessed using the following criteria: $< 0.2$ = trivial, 0.2–0.6 = small effect, $> 0.6$–1.2 = moderate effect, $> 1.2$–2.0 = large effect and $> 2.0$ = very large.[21]

In addition, T-test family sample power was calculated for a *Post-hoc* compute achieve power ($\alpha$ level = 0.05; ES = 0.8; and $n$ = 12) by the G-Power. There is an 82.8% (actual power) with the present analysis and sample.[22]

## Results

Descriptive results and comparisons between accumulated external training load data that preceded home and away matches, as well as data of home and away matches are presented in Table 1. Regarding matches,

**Table 1.** Comparison of home versus away match data and accumulated external training load that preceded home versus away matches per squad average, mean ± standard deviation. [AQ: 2]

| | Home matches (CI, 95%) | %CV | Away matches (CI, 95%) | %CV | $p$ |
|---|---|---|---|---|---|
| *Full-match* | | | | | |
| Duration (min) | 90.3 ± 4.6 (100.4–1.06.2) | 4.4 | 86.5 ± 8.4 (81.1–91.8) | 9.7 | < 0.001 |
| Total distance (m) | 9800.4 ± 898.4 (9229.5–10,371.2) | 9.2 | 9595.2 ± 10,001.2 (8959.1–10,231.3) | 10.4 | 0.127 |
| High-speed running (m) | 234.8 ± 92.7 (175.9–293.7) | 39.5 | 222.2 ± 78.1 (172.6–271.8) | 35.1 | 0.145 |
| Sprint (m) | 28.7 ± 16.8 (18.1–39.4) | 58.3 | 31.5 ± 16.6 (21.0–42.0) | 52.6 | 0.467 |
| Maximal speed (km $h^{-1}$) | 57.3 ± 2.8 (55.6–59.1) | 4.8 | 55.3 ± 3.6 (53.0–57.6) | 6.6 | 0.095 |
| Body load (au) | 168.1 ± 43.9 (140.1–196.0) | 26.2 | 161.6 ± 38.5 (137.1–186.1) | 23.8 | 0.432 |
| Metabolic power (W $kg^{-1}$), | 19.2 ± 1.6 (18.2–20.2) | 8.2 | 18.1 ± 2.3 (16.7–19.6) | 12.5 | 0.047 |
| AccZ1 (m $s^{-2}$) | 128.2 ± 12.5 (120.2–136.1) | 9.7 | 127.6 ± 20.5 (114.5–140.6) | 16.0 | 0.924 |
| AccZ2 (m $s^{-2}$) | 33. 9 ± 6.9 (29.6–38.3) | 20.2 | 36.3 ± 8.3 (31.1–41.6) | 22.8 | 0.290 |
| AccZ3 (m $s^{-2}$) | 4.7 ± 1.7 (3.6–5.8) | 36.0 | 4.1 ± 1.2 (3.3–4.8) | 28.8 | 0.054 |
| DecZ1 (m $s^{-2}$) | 53.2 ± 9.3 (47.3–59.1) | 17.5 | 50.0 ± 10.4 (43.4–56.6) | 20.8 | 0.267 |
| DecZ2 (m $s^{-2}$) | 24.6 ± 3.9 (22.1–27.1) | 16.1 | 22.6 ± 5.9 (18.9–26.4) | 25.9 | 0.127 |
| DecZ3 (m $s^{-2}$) | 8.6 ± 2.3 (7.1–10.0) | 26.8 | 8.4 ± 1.5 (7.4–9.4) | 18.3 | 0.803 |
| *Training preceding* | | | | | |
| Duration (min) | 319.8 ± 20.8 (306.2–332.6) | 6.5 | 285.6 ± 23.9 (270.4–300.8) | 8.4 | 0.002 |
| Total distance (m) | 17,879.3 ± 1402.1 (16,988.4–18,770.2) | 7.8 | 17,837.3 ± 2229.9 (16,420.5–19,254.2) | 12.5 | 0.950 |
| High-speed running (m) | 153.6 ± 72.0 (107.8–199.4) | 46.9 | 235.6 ± 99.3 (172.5–298.7) | 42.1 | < 0.001 |
| Sprint (m) | 6.4 ± 7.7 (1.4–11.3) | 121.6 | 9.4 ± 6.9 (5.0–13.8) | 73.9 | 0.208 |
| Maximal speed (km $h^{-1}$) | 102.3 ± 10.8 (95.4–109.2) | 10.6 | 97.5 ± 10.5 (90.8–104.1) | 10.7 | 0.149 |
| Body load (au) | 416.7 ± 100.1 (353.1–480.3) | 24.0 | 434.9 ± 173.0 (325.0–544.9) | 39.8 | 0.547 |
| Metabolic power (W $kg^{-1}$), | 21.9 ± 1.9 (20.6–23.1) | 8.9 | 22.5 ± 2.4 (20.6–23.1) | 10.8 | 0.352 |
| AccZ1 (m $s^{-2}$) | 228.0 ± 27.8 (210.4–245.7) | 12.2 | 221.6 ± 42.0 (194.9–248.3) | 19.0 | 0.522 |
| AccZ2 (m $s^{-2}$) | 69.6 ± 13.5 (61.0–78.1) | 19.4 | 68.3 ± 16.1 (58.1–78.6) | 23.6 | 0.736 |
| AccZ3 (m $s^{-2}$) | 6.3 ± 2.0 (5.0–7.5) | 32.2 | 6.4 ± 2.0 (5.2–7.7) | 31.3 | 0.672 |
| DecZ1 (m $s^{-2}$) | 27.7 ± 3.9 (25.5–30.0) | 12.7 | 25.2 ± 3.2 (23.2–27.2) | 12.6 | 0.034 |
| DecZ2 (m $s^{-2}$) | 32.8 ± 7.1 (28.3–37.3) | 21.8 | 31.8 ± 9.1 (26.0–37.6) | 28.7 | 0.503 |
| DecZ3 (m $s^{-2}$) | 8.2 ± 2.8 (6.4–10.0) | 34.2 | 7.8 ± 3.3 (5.8–9.9) | 41.7 | 0.531 |

CI: confidence interval; %CV: coefficient of variation; AccZ1: accelerations in zone 1 (< 2 m $s^{-2}$); AccZ2: accelerations in zone 2 (2 –4 m $s^{-2}$); AccZ3: accelerations in zone 3 (> 4 m $s^{-2}$); DecZ1: decelerations in zone 1 (> −2 m $s^{-2}$); DecZ2: decelerations in zone 2 (−2 to −4 m $s^{-2}$); DecZ3: decelerations in zone 3 (≤ −4 m $s^{-2}$).
*Significant differences, $p < 0.05$.[AQ: 4]

only two significant differences were found. Training duration [ES = 2.49, (1.44, 3.54)] and metabolic power [ES = 0.53, (−0.28, 1.34)] showed higher values in home than away matches.

Regarding accumulated training duration, there was a higher value for home matches than for away matches [ES = 1.51 (0.61, 2.41)]. In addition, there was a higher value in accumulated external training load that preceded away matches for high-speed running [ES = −0.95 (−1.79, −0.10)], and there was a higher value in accumulated external training load that preceded home matches for DecZ1 [ES = 0.75 (−0.07, 1.58)].

Figure 1 illustrates the comparisons between accumulated external training load and matches. In general, there were higher values for both scenarios in data related to home matches, with one exception for sprint (Figure 1(d)) where higher values were found in data related to away matches.

Figure 2 illustrates the comparisons between accumulated external training load and matches for acceleration and deceleration variables. All variables showed higher values for both scenarios in data related to home matches.

## Discussion

The purpose of this study was to compare external training load data that preceded a home versus away match, and also home versus away match data of GPS-derived variables. The results indicated that training duration and metabolic power showed higher values at home than away matches. In addition, there was a higher value in accumulated external training load that preceded away matches for high-speed running and DecZ1. But in general, it was observed that in all variables, such as duration, total distance, high-speed running, maximal speed, BL and metabolic power, the home matches had higher values, except for the high speed-running distance.

These data highlight the importance of match location. In general, studies on match location have shown that technical, tactical and behavioral factors are very influential.[17,23,24] Because at home, due to the hosting

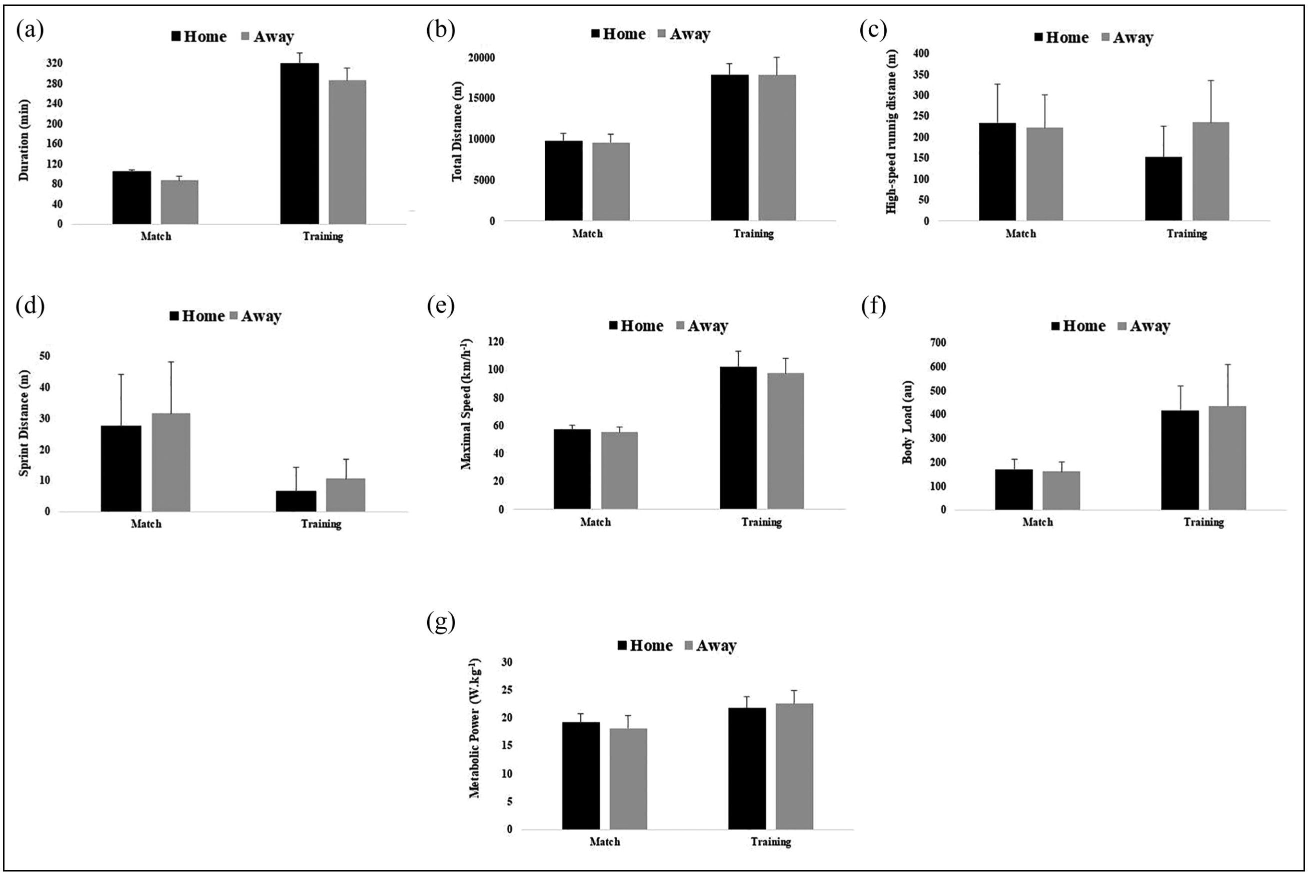


**Figure 1.** Differences of accumulated external training load data that preceded home and away matches, and differences of match data between home and away matches for (a) duration, (b) total distance, (c) high-speed running, (d) sprint, (e) maximal speed, (f) body load, and (g) metabolic power.

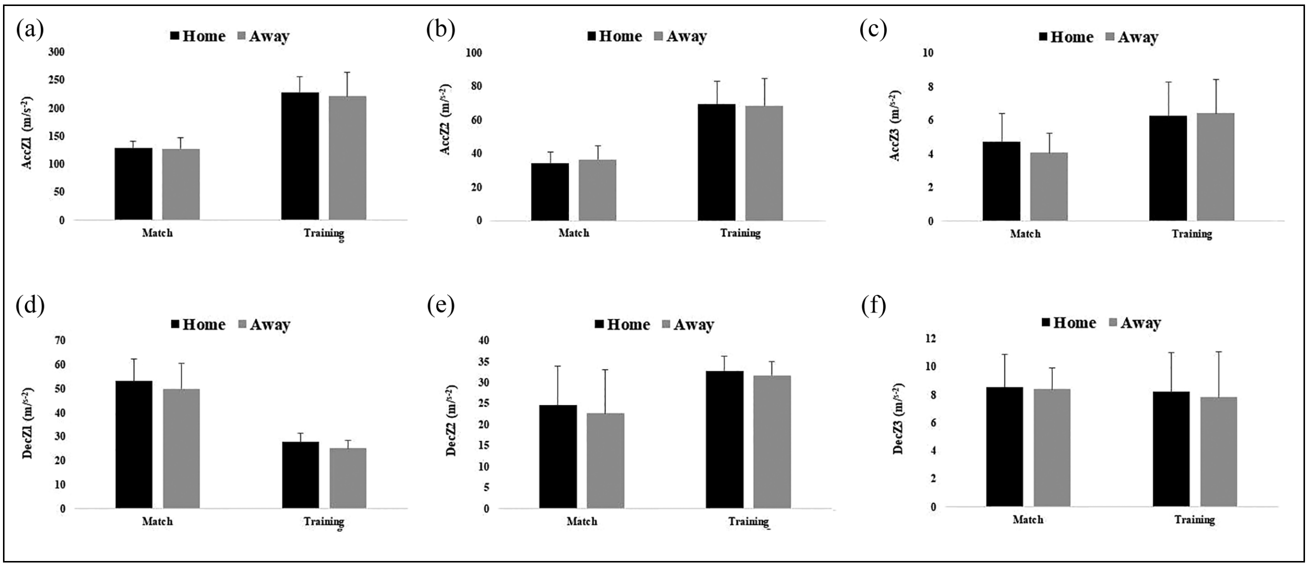


**Figure 2.** Differences of accumulated external training load data that preceded home and away matches, and differences of match data between home and away matches for (a) AccZ1, (b) AccZ2, (c) AccZ3, (d) DecZ1, (e) DecZ2, and (f) DecZ3.

conditions and home advantage, such as more spectators, familiarity with the field of match, and also high quality recovery between training sessions or post-matches, players are more inclined to train and play at home,[10,18] our results are similar with previous studies that reported that total training variation in home matches has a higher value.[3] In fact, the location of the match can be an effective factor in the outcome of the game.[23] Research shows playing matches at home produces more ball possession, attack actions (such as continuous passing), shooting, scoring and fewer defense activities and therefore increases the external load values. It has been seen in players, especially elite players, that they covered more distance playing at home than in the away games.[25] In general, the location of the game is very effective in the regular tactical arrangement of the players. Moreover, in a study that examined the performance of players during matches at home and away, it was concluded that in actions such as ball possession, long passes, ending actions, fouling actions and free-kicks, the performance of the players had a higher value when they played at home.[26] These results suggest that home teams use tactics that are more offensive, dominant and aggressive than their opponents.[26] However, the impact of playing at home or away has on playing style depends on the quality of the team(s). In other words, top-placed teams adopt a possession style of play suggesting they prefer to control the match by dictating play instead of giving the initiative to the opponent.[27] In fact, the top team tends to keep on playing aggressively, and this style involves less defense and more offense for gaining points at home.[26,28] This difference in style of play from home to away games actually means that players have more energy costs.[13] In fact, metabolic power has been introduced to estimate the energy demands of movements with changeable speed, such as acceleration and deceleration as main factors of energy cost, especially in team sports.[13] In the present study, the metabolic power, acceleration and deceleration values were higher in both home training and home competition, which is evidence of the fact that players in home games have a higher external load. On the other hand, better performance in home matches can be attributed to the presence of confidence, motivation and better conditions at home; because the playing field is very effective in mentally controlling stress and the desire to win. In addition, there are studies showing that indicators of wellbeing, such as mood, stress and sleep, are influenced by match location. Indeed, some of the non-performance related factors that could have affected mood and stress in the away matches include travel, unfamiliarity with surroundings, habit disruption, changes in food provision, pressure from away supporters, and sleep loss.[17,18] In qualitative interviews, travel and sleep loss were actually identified as being the two key reasons why soccer players preferred playing at home.[18]

In the present study, all external load variables had a higher value both training and match considering home situation. However, sprinting/high-speed running had higher level in training and away games. In fact, the needs of the away matches caused the coaches to use more sprinting in training, and this could be a seasonal training load strategy that strength and conditioning may be used in order to adapt players to the effect that contextual variables, such as match location may have on match performance.[23] There could be two different interpretations regarding the present results: on one hand, high-speed running and/or sprint distances could be used as a strategy for training when the next match is away; on the other hand, it could also be used a strategy to increase intensity when the next match is at home. Nonetheless, all interpretations should be considered in the context of the specific scenario of the team analyzed.

Concerning the limitations of the current study, three aspects should be highlighted. Contextual variables (e.g. opposition level and the score-line) were not taken into account and these variables may affect teams' performance and external load. More matches, seasons, different age groups of players and different competitions should be considered to provide conclusive descriptions and measures for playing performance and generalizability of the data. Finally, considering internal load and external load along with contextual variables may produce more complete results. For this reason, we strongly recommend that researchers consider it for future studies.

## Conclusion

In this study, we examined the external load variables based on match location. The results showed that the external load variables at home matches were in general higher than away matches. Indeed, external load variables had a higher value in home matches, which proves that players in home have better distance cover variables to earn points. However, the results showed that the sprint and high-speed running had higher value in away games, as well as in training, which could be the discretion of the coaches to prepare players for different conditions on the opponent's field.

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