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Original Article

High-intensity running and sprint distance prior to hamstring injury in elite male soccer players. Is there a common theme in over- or under- loading in the weeks preceding hamstring injury?

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Abstract

The analysis of the period prior to injury is still scarce in soccer. Thus, the aim of this study was to examine the loading patterns of high-intensity running and sprint distances during the weekly cycle durations across a five-year period in an elite soccer club. Specifically, to investigate any over- or under-loading in the weeks preceding hamstring injury. Thirty professional outfield soccer players from an English Premier League club were involved (age 24.2 ± 6.1 years, weight 74.7 ± 7.8 kg, height 1.81 ± 0.09 m). Injury surveillance, training and match data from the complete 2020/21 season was considered for analysis. Physical data were consistently monitored across the study seasons during all training sessions and matches using an 18Hz Global Positioning System (GPS) technology tracking system. The relative and absolute measures of total distance, high-intensity distance (m; total distance covered 5.5 - 7m/s) and sprint distance (m; total distance covered > 7m/s) were collected. These measures were analyzed considering the four weeks preceding injury (-4, -3, -2, -1) between injured and uninjured players. The main findings revealed that sprint distance per minute was higher in injured than uninjured players in the week preceding the injury (week -1, $p = 0.038$; ES = -0.89). No other meaningful differences were found. This study highlighted the influence of sprint distance per minute performed in the week preceding injury in elite English Premier League soccer players. Such findings highlight the importance of longitudinal measurements specifically related to sprint distance, while the analysis of two-, three- and four-weeks prior to injury does not seem to add any significant value. Finally, the data from the present study highlights the importance of analyzing relativized data (per minute) compared to absolute data.
Key words: absolute data; external load; football; hamstring injuries; high-speed running; GPS; relative data; sprinting.

Introduction

The most decisive moments during a soccer match include high-intensity actions such as sprints, jumps and change of direction (Castillo et al., 2021) and are associated with scoring a goal (Faude et al., 2012). Consequently, the application of an integrated approach, that includes athlete monitoring, may allow the understanding of mechanisms related to training stimulus and recovery (Gabbett et al., 2017). Thus, providing information on training periodization design and implementation, to support coaches to quickly identify individual player responses to stressful situations while also monitoring player wellness (Weaving et al., 2019).

Measuring external load can be easily applied when a global positioning system (GPS), global navigation satellite systems (GNSS), local positioning systems (LPS), and inertial measurement units that belong to micro-electro-mechanical systems (which provide a combination of 3D accelerometers, 3D gyroscopes, and 3D magnetometers) are employed (Oliveira et al., 2023). With such devices, performance indicators, such as

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high-speed running (HSR), sprinting, accelerations, and decelerations can be collected, allowing coaches and performance staff to comprehensively understand these variables that can be directly linked to successful match outcome (Tienza-Valverde et al., 2023).

According to a previous study, in professional male soccer, in each 1000 hours of training/match exposure, there are 8.1 injuries (López-Valenciano et al., 2019). If analyzed separately, in each 1000 hours of matches, there are 36 injuries compared to 3.7 injuries per 1000 hours of training (López-Valenciano et al., 2019). In addition, injuries can be sub-divided and classified by location; six hamstring, three quadricep, three adductor, one/two calf, and one/two 'other' muscle groups (McCall et al., 2015). Focusing on hamstring injuries, it has been suggested that biceps femoris is the most frequently injured (Raya-González et al., 2020).

Moreover, HSR and sprinting demands in soccer seem to be associated with 70% of hamstring injuries (Ekstrand et al., 2012). For instance, one study analyzed the differences in maximum velocity, high-intensity distances and sprint velocities by injury comparing these values to pre-injury data and found only slight improvements in these measures when the player returned to play (Jiménez-Rubio et al., 2020). Still, this study did not analyze what occurred in terms of HSR and sprinting prior to injury occurrence. Furthermore, recent studies tried to analyze identical scenario considering the impact of all injuries on match running performance following the return to competitive match-play over two consecutive seasons (Morgans et al., 2023, Raya-Gonzalez et al., 2022). Nonetheless, previous studies failed to analyze the period prior to injury. While the existing literature is scant, two studies analyzed such a period. One study examined HSR performance during match-play prior to and following a hamstring strain injury. The main findings reported that when players returned to match-play post-hamstring strain injury, reductions in high-speed match physical performance within normal match-to-match variation were observed. This study was conducted with data from Qatar Stars League (Whiteley et al., 2022). An additional study investigated total distance, HSR and accelerations during training and competition prior to an injury. While no differences were displayed considering accumulated load from the previous 7 or 14 days, other metrics displayed significant differences when analyzed over a period of 28 days. Notably, this study was conducted across three academy teams (2nd Team, U-19 team, and U-18 team) from an elite Spanish La Liga soccer club (Guitart-Trench et al., 2025). Furthermore, no research was found from the English Premier League, which supports the rationale for the present study.

Therefore, the aim of this study was to examine the loading patterns of total distance, high-intensity running and sprint distances during the weekly cycle durations across a one-year period in an English Premier League soccer club. Specifically, the aim was to investigate any over- or under-loading in the weeks preceding hamstring injury by comparing injured and uninjured players. Considering previous research, it was hypothesized that over-loading may be associated with higher hamstring injury occurrence (Raya-González et al., 2020). Furthermore, the present study considered previous research utilizing the use of relative and absolute differences to provide specific context (Miguel et al., 2021).

Methods

A retrospective analysis was performed examining injury and training and match data from an elite English Premier League soccer team. A member of the club medical department recorded daily player availability and injury data via a standardized format. As previously employed, definitions and data collection procedures in soccer injury research only administered and recorded time loss injuries (Fuller et al., 2006, Hoppen et al., 2022). Players that were previously injured at study commencement were included, although were not incorporated into the analysis, while new players recruited during the study period were included.

This research utilized a one-year longitudinal study design. A non-probabilistic sampling protocol was employed to recruit the participants. During the observational period of season 2020/21, consistent player monitoring approaches were practically implemented by club staff without any interference from the researchers.

Participants

Thirty professional outfield soccer players from an English Premier League club (age 24.2 ± 6.1 years, weight 74.7 ± 7.8 kg, height 1.81 ± 0.09 m) were involved in the study. Data for 30 senior players (first-team squad) from the complete 2020/21 season were included. The inclusion criteria for the study have previously been applied (Morgans, Ceylan et al., 2025, Morgans, Di Michele et al., 2025, Morgans, Ju et al., 2025) and were: (i) a registered first-team player at commencement of the examined season, (ii) consistently trained with the first-team team, (iii) participated in 80% (minimum) of training sessions and matches, and (iv) only participated in official club training during the study season. Additionally, the study exclusion criteria have also been employed (Morgans, Radnor et al., 2024, Morgans, Radnor et al., 2025) and included: (i) long-term (three months or longer) injury, (ii) joining the team following the season commencement, (iii) missing sections of training or match-play data, (iv) an in-sufficient number of satellite connection signals, and (v) goalkeepers, due to significantly differing positional demands.

Players were classified as: centre-backs (CB; n = 7), full-backs (FB; n = 4), centre midfielders (CM; n = 9), attacking midfielders (AM; n = 5), and centre forwards (CF; n = 5). If a player fulfilled multiple playing positions during match-play, the player was categorized accordingly to each position.

Prior to study implementation, written informed consent was collated from all participants. The study was conducted according to the requirements of the Declaration of Helsinki and was approved by the local Ethics Committee of Cardiff Metropolitan University and the professional club from which the participants volunteered (Winter and Maughan, 2009). To ensure confidentiality, all data were anonymized prior to analysis.

All injuries (n = 42, including minimal to severe injuries) recorded in outfield players (n = 30) from the study team across the 2020/21 season were considered. Among the 42 injuries, 12 different non-contact muscle strain injuries were considered for the analysis. The mean and standard deviation (SD) of number of absent days was 12.7 ± 16.9, with a range of 1 to 63.

Data collection

Each season was standardized based on the official fixture schedule of the respective league (English Premier League). The initial phase was classified as pre-season (early-July to mid-August) that lasted five to six weeks and the competitive season (mid-August to mid-May) that lasted 36 weeks.

All injuries were assessed, diagnosed, and categorized by the club's physiotherapist and head doctor and defined as injury incidence resulting in a modified training program, or missed training session/s or match/es (Rogalski et al., 2013, Morgans et al., 2023). Injuries were further categorized by body-site (injury location and region), injury type (trauma, overuse), sub-type (fracture, other bone injury, dislocation/subluxation, sprain/ligament, meniscus/cartilage, concussion, muscle strain, tendon, hematoma/contusion, nerve injury and synovitis), nature (training, match or undefined), description and days missed. However, only hamstring injuries were considered for analysis.

Physical data were consistently monitored across the study season during all training sessions and matches using an 18Hz Global Positioning System (GPS) technology tracking system (Apex Pod, version 4.03, 50g, 88 × 33mm; Statsports; Northern Ireland, UK) that has been previously validated in a student population for tracking distance covered and peak velocity during simulated team sports and linear sprinting (Beato et al., 2018). The acquisition of satellite signals and synchronisation of the GPS clock and the satellite's atomic clock was achieved and previously documented (Maddison et al., 2009). A 2.5% estimation error for distance covered has been reported, with accuracy improving as the distance covered increased and the speed of movement decreased (Beato et al., 2016). The GPS system employed has found excellent inter-unit reliability (Beato et al., 2019), however, to avoid any inter-unit variation players wore the same GPS unit for each training session and match (Thornton et al., 2019). The GPS signal quality and horizontal dilution of position (HDOP) was connected to a mean number of 21 ± 3 satellites, range 18-23, while HDOP for all seasons ranged between 0.9-1.3.

Following every training session or match, GPS data were extracted and processed prior to analysis using proprietary software (Apex, 10 Hz version 4.3.8, Statsports Software; Northern Ireland, UK) as software-derived data is easier and more efficient for practitioners to obtain data in an applied environment, with no differences reported between processing methods (software-derived to raw processed) (Thornton et al., 2019). The dwell time (minimum effort duration) was set at 0.5s to detect high-intensity running and 1s to detect sprint distances, in-line with manufacturers recommendations and default settings to maintain consistent data processing (Thornton et al., 2019). Furthermore, the internal processing of the GPS units utilized the Doppler shift method to calculate both distance and velocity data which is shown to display a higher level of precision and less error compared with data calculated via positional differentiation (Townshend et al., 2008).

The absolute distances of total distance covered (m); high-intensity distance (m; total distance covered 5.5 - 7m/s); and sprint distance (m; total distance covered > 7m/s) were examined and have been established based on previous studies (Wass et al., 2020, Riboli et al., 2020). Relative distances covered per minute (m/min) in the following categories: total distance, high-intensity distance, and sprint distance were also observed.
Considering previous research, both absolute and relative distances were analyzed considering the four weeks preceding injury (-4, -3, -2, -1) between injured and uninjured players (Duhig et al., 2016).

Statistical analysis

Visual Studio Code, with Python, utilized as the programming language, was used for all statistical analyzes. Independent t-tests were used to compare the absolute and relative total distance, high-intensity and sprint distances covered during the study season between the injured and uninjured players. The standardized differences were used as effect sizes and were evaluated as trivial (<0.2), small (0.2-0.6), moderate (0.6-1.2.0), large (1.2-2.0), very large (2.0-4.0) and extremely large (>4) (Cohen, 2014). Statistical significance was set at $p<0.05$.

Results

Table 1 depicts the mean ± SD for total distance covered by players, revealing a similarity between both groups, albeit a slight decrease in total distance covered by injured players in the week (-1) preceding injury. Still, no significant differences between groups were observed for weeks -4, -3, -2, and -1.

Regarding total sprint distance, no statistically significant difference is observed, although a consistent trend emerges for injured players consistently covering greater sprint distance compared to non-injured players leading up to the injury (week -1). Similar observations are noted for total high-intensity distance covered. Despite the lack of statistical significance, it is noteworthy that injured players consistently performed greater distances. Independent t-tests were further conducted for metrics per minute to account for variations in individual match minutes (Table 2). Notably, for total distance covered per minute, no statistical differences were observed across any week. Similarly, no differences were displayed in high-intensity distance covered per minute. However, for sprint distance per minute, contrasting results were observed, with a significant difference found in the week preceding the injury (week -1). No other differences were found in any other weeks (-4, -3, -2).

TABLE 1. The absolute mean values and estimated differences for injured and uninjured players during the 2020-2021 season.

		Mean ± SD		Injured / Uninjured estimated difference (95 % CI)	p value	ES
Metrics	Weeks	Uninjured	Injured			
Total distance	-4	9678.12 ± 1009.19	9486.10 ± 909.44	192.03 (-685.13, 1069.18)	0.693	0.19
	-3	9497.26 ± 1029.86	9580.32 ± 900.85	-83.06 (-1028.04, 861.92)	0.878	-0.08
	-2	9707.64 ± 1129.51	9386.75 ± 1202.44	320.89 (-795.62, 1437.40)	0.553	0.28
	-1	9715.68 ± 1143.33	9017.09 ± 1097.83	698.59 (-216.82, 1614.10)	0.151	0.61
High-intensity distance	-4	714.51 ± 191.37	784.18 ± 130.71	-69.66 (-201.57, 62.24)	0.442	-0.37
	-3	742.91 ± 225.46	797.43 ± 82.72	-54.52 (-157.68, 48.64)	0.638	-0.25
	-2	646.61 ± 174.42	719.87 ± 104.63	-73.26 (-177.65, 31.13)	0.367	-0.43
	-1	696.72 ± 199.27	696.72 ± 199.27	-45.84 (-201.67, 109.98)	0.587	-0.23
Sprint distance	-4	139.01 ± 66.93	186.07 ± 50.34	-47.07 (-96.95, 2.82)	0.143	-0.72
	-3	150.05 ± 92.03	177.12 ± 64.68	-27.07 (-96.54, 42.40)	0.572	-0.30
	-2	128.43 ± 70.75	147.09 ± 67.99	-18.67 (-82.31, 44.98)	0.579	-0.26
	-1	139.47 ± 76.54	202.70 ± 112.13	-63.22 (-155.15, 28.71)	0.061	-0.81

Abbreviations = -4: four weeks prior to injury; -3: three weeks prior to injury; -2: two weeks prior to injury; -1: one week prior to injury; CI: confidence interval; ES: effect size; SD: standard deviation

TABLE 2. The relative mean values and estimated differences for injured and uninjured players during the 2020-2021 season.

		Mean ± SD		Uninjured / Injured estimated difference (95 % CI)	p value	ES
Metrics	Weeks	Uninjured	Injured			
Total distance per minute (m)	-4	105.87 ± 8.46	106.41 ± 6.46	-0.53 (-6.91, 5.85)	0.895	-0.06
	-3	105.53 ± 9.77	103.68 ± 5.90	1.85 (-4.64, 8.33)	0.716	0.19
	-2	105.58 ± 8.38	106.72 ± 4.78	-1.14 (-5.95, 3.68)	0.770	-0.14
	-1	105.95 ± 8.97	102.41 ± 7.82	3.54 (-3.03, 10.10)	0.352	0.40
High-intensity distance per minute (m)	-4	7.92 ± 2.42	8.88 ± 1.73	-0.96 (-2.69, 0.77)	0.405	-0.40
	-3	8.33 ± 2.67	8.68 ± 1.13	-0.34 (-1.69, 1.02)	0.801	-0.13
	-2	7.17 ± 2.37	8.19 ± 0.67	-1.02 (-1.89, -0.15)	0.349	-0.44
	-1	7.66 ± 2.29	8.53 ± 2.25	-0.87 (-2.74, 1.04)	0.371	-0.38
Sprint distance per minute (m)	-4	1.56 ± 0.83	2.14 ± 0.73	-0.58 (-1.29, 0.13)	0.150	-0.71
	-3	1.67 ± 1.01	1.97 ± 0.83	-0.29 (-1.17, 0.58)	0.573	-0.30
	-2	1.44 ± 0.90	1.64 ± 0.64	-0.19 (-0.81, 0.43)	0.648	-0.22
	-1	1.53 ± 0.86	2.31 ± 1.13	-0.78 (-1.71, 0.15)	0.038	-0.89

Abbreviations = -4: four weeks prior to injury; -3: three weeks prior to injury; -2: two weeks prior to injury; -1: one week prior to injury; CI: confidence interval; ES: effect size; SD: standard deviation

Discussion

The aim was to investigate any over- or under-loading of total distance, high-intensity distance, and sprint distance in the weeks preceding hamstring injury by comparing injured and uninjured players. The main observations from this study suggest that regarding the physical activity patterns of injured and uninjured players in the four weeks leading up to injury, total distance was similar, although injured players performed greater volumes of sprint and high-intensity distances than uninjured players. However, one meaningful result was noted in week -1 for sprint distance per minute in which higher values were detected in injured players.

Initially, in terms of total distance, both groups exhibited a similar mean ± SD, indicating comparable levels of overall activity. However, a marginal decrease in total distance covered was observed among injured players during the week preceding injury. Despite this, statistical analysis revealed no significant differences between injured and uninjured players across the weeks examined (-4, -3, -2, and -1). This may partly be attributed to the potential of this volume metric (total distance) not contributing towards the higher velocity metrics, such as sprint and high-intensity running, that are regarded as significant in injury risk. This finding is in line with previous research in Australian football players (Duhig et al., 2016).

Considering absolute sprint distance and high-intensity distance covered, while no statistically significant differences were observed, a consistent trend emerged. Injured players consistently surpassed uninjured counterparts in both sprint and high-intensity distances leading up to injury, particularly in week -1. Although these differences did not reach statistical significance, the intriguing debate regarding the potential relationship between heightened physical exertion and injury susceptibility are raised and again corroborating previous research (Duhig et al., 2016). In particular, the breakdown of the sprint distance volume across the microcycle was not examined, only the total sum for the weekly period, thus a detailed breakdown of where in the microcycle (match-day -4, -3, -2, -1) these sprint distances occurred may partly explain the injury moments. For example, was sprint distance higher in week -1 for an injured player on match-day -3, or was it micro-dosed across all training days leading into the match. Nonetheless, such analysis was beyond the focus of the current study.

Further analysis regarding relative external load measures (per minute) was performed to account for variations in individual playing duration, which may potentially influence the present results. Interestingly, total distance and high-intensity distance covered showed no statistically significant differences across the examined weeks (-4, -3, -2, and -1) preceding injury. This suggests that when accounting for variations in playing time, high-intensity distance and total distance covered by players remain relatively consistent regardless of injury status. While total distance seems to be easily explained by the fact that it is a measure of volume rather than intensity, high-intensity distance has been reported as a measure with association with injuries (Gabbett et al., 2012, Duhig et al., 2016).

However, the sprint distance covered per minute yielded more varied results. While no statistical differences were found in most weeks (-4, -3, -2), a significant discrepancy emerged in the week prior (-1) to injury, where injured players covered significantly greater sprint distances compared to uninjured players. This finding may indicate a potential warning sign, suggesting that a sudden increase in sprint activity relative to playing time may be associated with an elevated risk of injury and partly explain the hamstring injury occurrence. On the one hand, the significant finding in week -1 is in line with a previous study that reported identical results however, this finding occurred in a different measure, namely, high intensity running (Duhig et al., 2016). Additionally, individualized running speed thresholds could provide greater knowledge regarding the dose-response relationship between external load and its association with injury risk, as previously suggested (Clemente et al., 2023). Nonetheless, it is relevant to mention that the present analysis accounted the need for a proper stimulus/load to improve performance or maintain performance and consequently, the typical mesocycle of four weeks in soccer was used (Morgans et al., 2014, Oliveira et al., 2019). Moreover, previous research about acute:chronic workload ratio typically characterized by the division of the accumulated load of current week (microcycle) by the 28-day rolling average or the previous four weeks (known as chronic load) which support the rational of the current study (Gabbett et al., 2016, Hulin et al., 2016). Thereafter, this study seems to corroborate the previous assertion that decreasing sprint distance in the fourth week of each mesocycle (month) may prevent injury risk, although the previous study was related to high intensity running (Gabbett and Ullah, 2012). A practical application may be the implementation of a recovery or tapered week in the fourth week (Duhig et al., 2016) of a mesocycle.

In summary, the results suggest that while overall physical activity levels may not significantly differ between injured and uninjured players with the exception for sprint distance per minute analysis. These findings support the suggestion that examining sprint distance per minute and managing player workload, especially sprint distances (>7m/s), to mitigate injury risks in elite soccer settings, are warranted. Further research exploring the interplay between activity intensity, playing time, and injury occurrence is warranted to enhance injury prevention strategies in elite soccer.

Limitations and Future Research Recommendations

The study had a limited sample size by focusing on the specific examined population, which may affect the generalizability of the findings to other contexts (other clubs, leagues, standard of competition) or athlete populations. Larger and more diverse samples are needed to ensure broader applicability of the results. In addition, only sprint distance was analyzed, while the number of contextual sprints may be particularly relevant to provide additional context. There were other factors influencing the observed relationship between activity intensity and injury susceptibility that were not accounted for in the study. Confounding variables such as player fitness levels, playing style, congested fixtures or previous injury history could potentially confound the results. While the study identifies associations between activity intensity and injury susceptibility, it cannot establish causality. Other factors not measured or considered in the analysis may contribute to both increased activity intensity and injury risk, making it challenging to infer causation. Finally, the study focused on activity patterns leading to injury but does not provide insight into the temporal relationship between increased activity intensity and the onset of injury.

Another suggestion for future studies is using the acute:chronic workload ratio. For instance, a recent systematic review suggested that a ratio around 1.50 could predict higher risk (Rico-Gonzalez et al., 2023).

Moreover, another recent study found that 25% of the analyzed players presented a ratio higher than 1.5 for very high intensity running distance (>6 m/s) (Ribeiro-Alvares et al., 2023) which is identical to the current threshold of the present study used for sprint distance. Furthermore, training monotony is another variable used as a predictor of injury risk. Training monotony represents the division of average load of the week by the standard deviation of that same week (Foster, 1998). Therefore, using this type of ratio and prediction analysis could provide additional insights for coaches and performance and medical staff. Additionally, the analysis of accumulated absolute data (e.g., from the last four weeks) may have provided different results and for that reason it should be considered for future studies (Guitart-Trench et al., 2025). Finally, the use of contextualized variables (e.g., ball in- and out-of-possession, playing position, match location and opponent ranking) along with acceleration/deceleration metrics would provide additional insights (Morgans, Mandorino et al., 2025). Longitudinal studies with more frequent and detailed data collection points are needed to better understand the timing and progression of injury risk factors. Acknowledging these limitations is crucial for interpreting the findings accurately and guiding future research efforts to address gaps and refine injury prevention strategies in elite soccer.

Practical Applications

Coaches and performance staff should implement robust monitoring systems to track players' physical activity patterns, especially in the weeks preceding injury. Regular assessment of total distance, sprint and high-intensity distances covered can provide valuable insights into players' workload and potential injury risks. The observed increase in sprint distance covered per minute among injured players in the week (-1) leading up to injury serves as a potential warning sign. Coaches, performance and medical staff should pay close attention to sudden spikes in activity intensity relative to playing time, as these may indicate an elevated risk of injury. Understanding the relationship between activity intensity and injury susceptibility may inform the design of training programs. Thus, coaches can adjust training loads and intensity levels to minimize injury risks while optimizing players' performance and fitness levels. Furthermore, recognizing that injury susceptibility may vary among players, an individualized approach to training and workload management is essential. Factors such as player position, injury history, and physical condition should be considered when designing training programs and monitoring workload. By incorporating these implications into practice, elite soccer clubs can enhance injury prevention strategies and optimize the health and performance of players.

Conclusions

In conclusion, this study highlighted that English Premier League players with higher sprint distance per minute tended to develop a hamstring injury compared with players that did not. However, no other metric analyzed, absolutely or relatively, showed any significant difference. Such findings highlight the importance of longitudinal measurements specifically related to sprint distance, while the analysis of two, three- and four-weeks prior to injury does not seem to significantly contribute any additional information.

Furthermore, the data from the present study highlights the importance of analyzing relative data (per minute) for greater granularity when compared with absolute data. Future studies should attempt to confirm the present results, while also developing this concept by analyzing the number and distance of sprinting in the context of match-play for additional knowledge.

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