Match High-Speed Running Distances Are Often Suppressed After Return From Hamstring Strain Injury in Professional Footballers

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Background: High-speed running is commonly implicated in the genesis of hamstring injury. The success of hamstring injury management is typically quantified by the duration of time loss or reinjury rate. These metrics do not consider any loss in performance after returning to play from hamstring injury. It is not known to what extent high-speed running is altered on return to play after such injury.

Hypothesis: Match high-speed running distance will change after returning from hamstring injury.

Study Design: Non-randomized cohort.

Level of Evidence: Level 3.

Methods: Match high-speed running distance in highest level professional football (soccer, Rugby League, Rugby Union, and Australian Rules) were examined for a minimum of 5 games prior and subsequent to hamstring strain injury for individual differences using a linear regression models approach. A total of 22 injuries in 15 players were available for analysis.

Results: Preinjury cumulative high-speed running distances were strongly correlated for each individual (r^2 = 0.92-1.0; $P < 0.0001$). Pre- and postinjury high-speed running data were available for a median of 15 matches (range, 6-15). Variance from the preinjury high-speed running distance was significantly less ($P = 0.0005$) than the post injury values suggesting a suppression of high-speed running distance after returning from injury. On return to play, 7 of the 15 players showed a sustained absolute reduction in preinjury high-speed running distance, 7 showed no change, and 1 player (only) showed an increase. Analysis of subsequent (second and third injury) return to play showed no differences to return from the index injury.

Conclusion: Return to play was not associated with return to high-speed running performance for nearly half of the players examined, although the same number showed no difference. Persisting deficits in match high-speed running may exist for many players after hamstring strain injury.

Clinical Relevance: Returning to play does not mean returning to (high-speed running) performance for nearly half of the high-level professional football players examined in this study. This suggests that successful return to play metrics should be expanded from simple time taken and recurrence to include performance.

Keywords: hamstring; performance; shared decision making; return to sport; professional; football

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Hamstring strain injury in football has a reported season prevalence of 17%, and match and training incidences of 3.70/1000 hours and 0.92/1000 hours, respectively—comfortably exceeding the burden of any other lower limb muscle injury[14] and remains the largest time-loss burden in professional football. As such, it has been a focus of significant attention with regard to prevention and treatment approaches in an effort to minimize this problem.[5,14-19,21,22,30] Hamstring injury prevention programs typically document their efficacy and effectiveness by reporting incidence or prevalence of time-loss hamstring injuries.[2,25] Similarly, randomized trials of different treatment approaches such as progressive agility and trunk stability,[25] additional early lengthening exercises,[3,4] and pharmacological interventions [20,24] have also used time to return to sport as the primary outcome. Such time-loss definitions do not reveal any injury burden that reduces performance if the player still participates in training or matches.[1] Widening injury definitions to include “any medical attention” still may miss information regarding reduced sporting performance if the player is able to participate in training or matches, albeit at reduced ability. For this reason, an “injury burden” approach has been proposed[8,9] recording the athlete’s perception of any difficulty in training or matches irrespective of medical attention or time loss.

This work exposed the extent of previously underreported perceived performance reductions in training and match play due to athletes “carrying” injuries. An extension of this work, we speculated, may be examining actual performance decrements associated with injury, which may shed further light on injury burden. Any performance metric considered, of course, would need to be specific to both the injury and the sport. High-speed running ability is considered an important aspect of the performance and therefore preparation of many professional football players.[6] The total distance of high-intensity running and sprinting differentiates between international and lower-level professional football players.[23] Sprinting is the reported mechanism of injury in over 70% of football players’ hamstring injury,[4] and in over 90% of track athletes’ injuries.[3] We therefore speculated that the amount of high-speed running could be considered a reasonable proxy of performance decrement after hamstring strain injury in football players. It is not known to what extent professional football players restore their high-speed running performance after hamstring strain injury.

Accordingly, this retrospective study sought to document the high-speed running distance performed by individual players prior and subsequent to hamstring strain injury to assess the degree to which these players return to preinjury performance levels.

METHODS

Ten professional football teams (Association Football–soccer, Rugby League, Rugby Union, and Australian Rules Football), all playing at the highest level of competition in their respective sports were contacted and asked to take part in this study on condition of player and organizational anonymity. Five teams agreed to provide anonymized routinely collected match high-speed running data for 22 consecutive hamstring strain injuries (Figure 1).

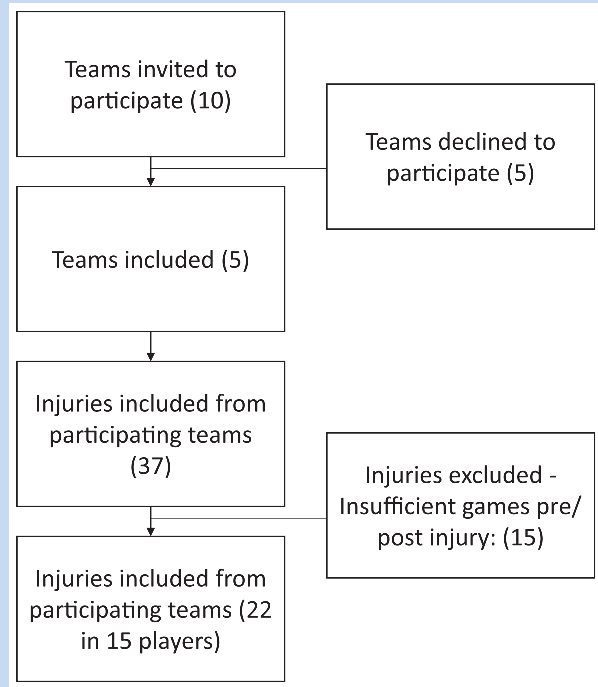

Figure 1. Inclusion flowchart.

Hamstring strain injuries were diagnosed by the respective medical teams in their usual manner including any combination of patient history, physical examination, and follow-up imaging as required. All organizations had unrestricted access to diagnostic ultrasound, magnetic resonance imaging, radiography, and computed tomography imaging, which could be used as clinically indicated to augment the sports medicine practitioner’s examination. All injuries included a minimum of positive magnetic resonance imaging evaluation as part of the imaging workup. The rehabilitation and return to sport process was made by these same medical teams in consultation with the player and the performance staff as is usual practice.

These data were then retrospectively analyzed to examine for any differences in match high-speed running before and after rehabilitation from injury. Arbitrarily it was decided a priori that inclusion criteria for the study were professional football players for whom match high-speed running data were available for a minimum of 5 complete matches prior and subsequent to a verified hamstring injury. Match high-speed running data had to be available for an entire season for any injured athlete. The definition of high-speed running varies by sport and organization, however, within an organization this remained constant and was an inclusion criterion. These data were all collected as part of routine performance analysis and were either done via the use of validated video analysis[28] or the use of validated wearable Global Positioning System (GPS) sensors[13,29] as allowed by the regulations of the sport. Each of these approaches has been independently validated[7] and these data are captured and analyzed by sports scientists employed by the respective organizations. Any individual (player) analyses were conducted using the same thresholds considered to be high speed by the individual organization for routine performance and preparation purposes and were the same values for the pre- and postinjury data. Descriptive and inferential statistics were used to examine the preinjury high-speed running distance compared with postinjury with the individual players considered random effects. Initially, the data were examined for normality (histograms, normal-quantile plots, and Shapiro-Wilk tests), and then group differences (pre- and postinjury) were inspected. To explore the impact of hamstring strain injury on high-speed running distances, regression analysis was performed between accumulated high-speed distance and game sequence. This analysis was based on the assumption that high-speed running distance would accumulate over the matches at a rate specific to the individual prior to injury. To verify this assumption, individual linear fits were made of the accumulated high-speed running distance for each player as a function of the games played leading up to the injury. This approach allows description of the individual's variation from one's typical high-speed running distance (the r^2 value for that player's individual linear fit) and a description of the between-participant differences in high-speed running distance (the slope of each player's linear fit). Players who typically perform more high-speed running in a game will have steeper linear fits than those who do not, and the degree to which the individual points converge to the linear fit will be a representation of the between-game player variability. Provided the individual fits prove acceptable (assessed by the r^2), then the individual player linear fit slopes can be used to project postinjury distances. For each regression model, the predicted high-speed distance was subtracted from the actual high-speed distance by match to yield residuals that can be used to estimate pre- and postinjury differences. Because of nonnormal distribution of the residual data set, the whole data set was reduced to the median residual pre– and post–high speed distance per injury and comparisons made using a paired *t* test. The median value was used since it is more robust to outliers than the mean.

Ethics approval for the study was obtained (Anti Doping Lab Qatar Research Ethics Committee, approval No. E2017000264) and the study was conducted in accordance with the Declaration of Helsinki.[31]

RESULTS

The application of the strict inclusion criteria meant that of the initial 5 teams agreeing to take part, data from 15 professional players only were included in the final analysis (Table 1). The professional organizations included had a scheduled season comprising between 16 and 38 rounds. For the codes with fewer games, where typically only 1 game per week is played, this meant a very narrow window of possibility to include a hamstring injury, as it had to occur at least 5 weeks after the start of the season, and rehabilitation had to be completed more than 5 weeks prior to the season's completion. A sample of 22 instances of hamstring strain injury (including 7 reinjuries), that included up to 15 matches preinjury (minimum = 6, median = 15) and 15 matches postinjury (minimum = 6, median = 15).

Table 1. Player demographics

Player Demographics	M (SD, Range)
Age, years	25.18 (4.17, 18-34)
Height, m	1.81 (0.07, 1.68-1.93)
Weight, kg	74.03 (5.96, 62-85)
Body mass index, kg/m^2	22.46 (0.98, 20.56-24.08)

To explore any changes in high-speed running after hamstring injury, we used a 3-step process. First, we looked at the amount of high-speed running done by each player in the games leading up to the injury. To account for between-player differences, we looked at the accumulated high-speed running as a function of the games leading up to the injury. If players were performing roughly the same amount of high-speed running each game, then this accumulated high-speed running distance would linearly increase over games (Appendix Figure A1, available in the online version of this article). This approach allows description of the individual player variability by examining each linear fit for each player. Additionally, we described the between-player differences by considering the slope of these curves: steeper curves mean greater high-speed running distance observed each game. Next, once the veracity of the baseline individual high-speed running values were established, we used these values to create player-specific predictions for the amount of baseline (preinjury) high-speed running that is usual for this athlete. Any deviation from this preinjury predicted value (higher or lower) can then be described at an individual (Figure 2) or group (Figure 3) level. Figure 2 shows the cumulative high-speed distances by each player over a possible 30 matches where zero represents the time period associated with the hamstring strain injury (−15 = 15 matches prior and +15 = 15 matches after). Fits for all preinjury data were good (r^2 range = 0.92-1.0; $P < 0.0001$) and confirmed the assumption that high-speed running distance would accumulate over the matches at a rate specific to the individual prior to injury (Appendix Figure A1, available online). Note that these data also demonstrated large between-individual variability—from approximately 75 to 1000 m of high-speed running per game for different players (individual slopes in Appendix Figures A1 and A2, available online).

From the formula for each best fit, projected estimates for future games were determined (ie, what the expected

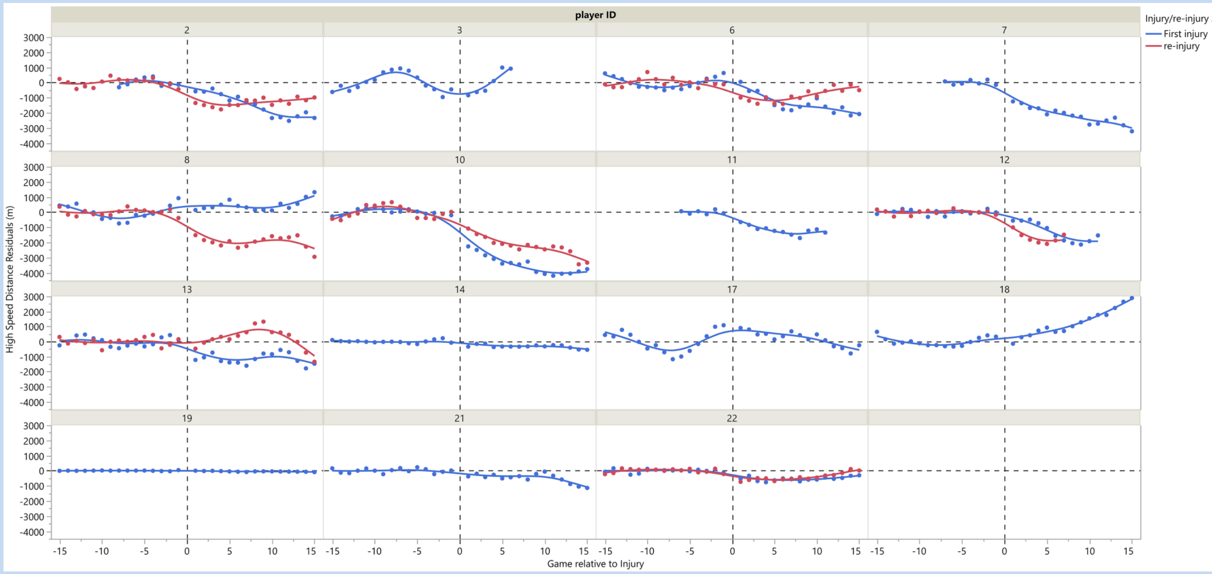

Figure 2. Variation in actual high-speed running distance (in meters) from predicted high-speed running distance for each individual prior and subsequent to hamstring strain injury. Each panel represents an individual player's data, negative *x*-axis values represent games prior to the hamstring injury, positive values represent games after the injury. Where more than 1 injury occurred, the first injury data are presented in blue, and the second injury (reinjury) in red. Each data point represents a deviation from the predicted high-speed running distance for the individual player. Positive values mean the player ran greater distance at high speed, and negative values mean the player ran less on that game than the predicted amount given the player's preinjury data. The available data pre- and postinjury were ranged from 6 to 15 (median 15 for each) and represents all matches that season before and after the injury.

cumulative distance would be if the preinjury trend for an individual player's high-speed running distance per game continued after returning from injury). This formed the predicted distance for the postinjury scores. When projected cumulative high-speed distances were compared with the actual corresponding postinjury data once the players had returned to competition, the residual score (actual high-speed distance – predicted cumulative high-speed distance covered) by match relative to the instance of injury was obtained, and the trends are presented in Figures 2 and 3. The general trend of a suppressed distance (ie, lower than predicted high-speed running distance postinjuries) for those who sustained a hamstring strain injury can be seen (Figure 3; Appendix Figure A3, available online) ($P = 0.0005$). However, reinjury had little additional impact. Figure 2 shows that despite trends, individual responses were very clear. Specifically, 7 players reduced their high-speed running distances, 7 players had comparable high-speed distances, and only 1 footballer increased his high-speed running distances after returning from injury.

DISCUSSION

The results of the present study show that in nearly half the players examined, return to play after hamstring strain injury in professional football is associated with a reduction in individual high-speed running distance. However, it should also be noted that nearly half of the players examined showed no change in high-speed running distance, and 1 player increased high-speed running distance. The group trend of reduced high-speed running distance after return from hamstring injury likely has performance implications for these top-level professional athletes.

The 2016 return-to-sport consensus meeting[1] suggested that athletes may consider return to sport a success depending on the time taken, whereas coaches may be more focused on the performance ability of the athlete upon return. High-speed running ability is widely viewed as a critical performance measure in various football codes.[6,10,11,23,27] The current data suggest that, at least in terms of high-speed running distance, many athletes may not be returning to their same level of performance.

The data presented here appear to show a persisting decline in high-speed running distance for up to 15 matches after return to play in 7 of the 15 professional athletes examined. It is not known if these players ultimately restored their preinjury high-speed running distances after a further period of time, or if this was their "new normal." Examining longer term trends might shed some light on the physiological healing process.

The relatively small absolute number of reinjuries (7) prevented meaningful subgroup analyses; however, the limited available data suggest that reinjury was not associated with a further decline in high-speed running performance. This may

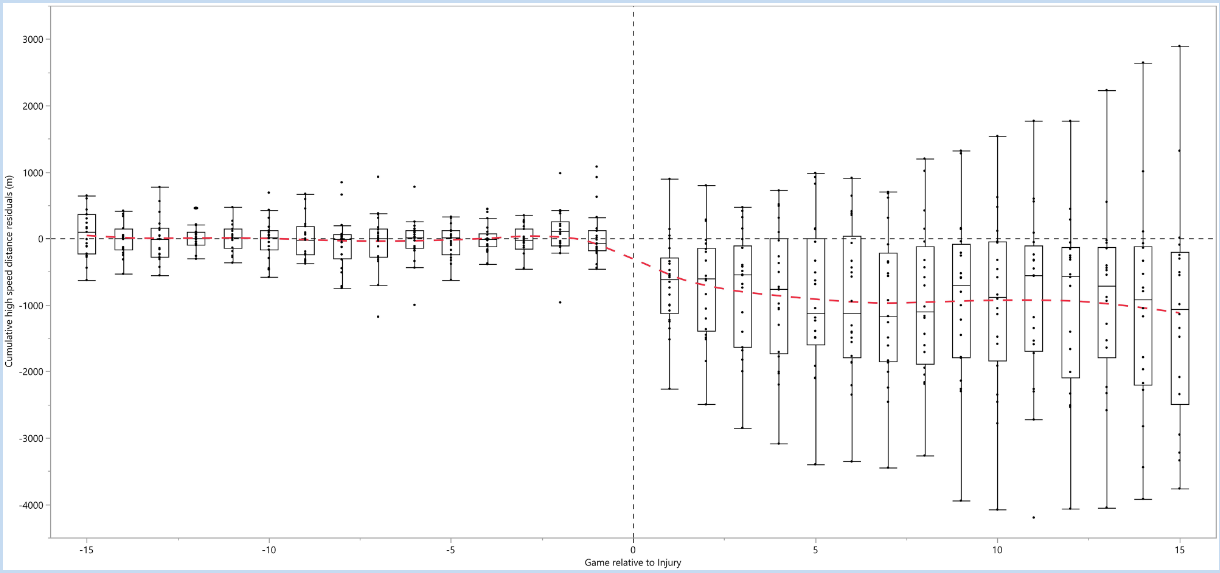

Figure 3. Cumulative high-speed running distance residuals by game for all injury instances. The *y*-axis represents the deviation from the predicted high-speed running distance for each individual. Note the relatively tightly clustered values preinjury suggesting little game-to-game variance in high-speed running distance confirming the assumption of little within-individual variability in high-speed running preinjury, and the much larger variation after injury. The group mean is represented by the dashed red line showing a typical suppression of approximately 1000 m in high-speed running postinjury, but note the wide variance in these data.

point to the establishment of a "new normal" after the index injury; however, this speculation requires much further scrutiny. The wide variability in the individual players' average high-speed running distance (the slopes of Appendix Figures A1 and A2, available online) suggest that more research is required to meaningfully describe whether alterations are related to the absolute amount of high-speed running typically performed by a player, or some other factors.

The shared decision-making model of return to sport[12] noted that the coach must consider the "ability to perform." The current data suggest that, at least in terms of high-speed running distance after hamstring strain injury, these goals are often not being met. It remains to be seen whether return to performance can be improved through alterations in rehabilitation strategy or whether doing so results in better actual football performance (ie, games won). Either way, it is likely that this somewhat surprising finding should be discussed with coaching and selection staff and factored into the shared return to sport decision-making process. Perhaps for some players there may be additional return to sport criteria of high-speed running distances.

Limitations

A large proportion of the initially invited organizations either declined to participate or their data were not able to be used because of the strict inclusion criteria and the sensitivities associated with publishing performance data for high-level professional athletes. Specifically, to include at least 5 matches pre- and postinjury, as well as time lost through rehabilitation in a single season was problematic in sports where only 1 match is played per week, with seasons as short as 16 matches. This has reduced the power of the present study and prevented any meaningful subgroup analyses, as such the current paper is perhaps best considered an exploration of proof of concept. Future research with larger samples may examine differences between sports, playing positions, and preinjury high-speed running distances, as well as examining longer term trends beyond the single season analysis done here. The current research has not accounted for variation in rehabilitation approaches and better-powered research may examine the effect of prolonging rehabilitation or prioritizing high-speed running to accrue greater high-speed running distance prior to return to sport.[26] Successful football performance depends on many factors including high-speed running. It may transpire that for some players, high-speed running ability is not crucial to their performance and that they are able to maintain high levels of playing performance through their technical and tactical abilities.

CONCLUSION

Almost half of the professional football players examined reduced their match high-speed running distance after returning from a hamstring strain injury. This reduction in high-speed running performance persisted for the remainder of the season. These findings suggest that return to play is often not associated with return to high-speed running performance after hamstring strain injury in professional football. Where this is important for an individual, it is recommended that additional attention be paid to high-speed running during the rehabilitation and return-to-sport process.

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