UNDERSTANDING THE IMPACT OF HAMSTRING INJURIES ON MATCH PERFORMANCE IN SPANISH PROFESSIONAL SOCCER PLAYERS: TWO FULL SEASONS FOLLOW-UP

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Abstract:

This study aimed to analyze the changes in match physical performance in professional soccer players after sustaining a hamstring injury, which was categorized based on injury severity. Seventy-two hamstring injuries involving sixty-four professional soccer players from the Spanish LaLiga™ were considered for this study. All injuries were classified according to their severity as moderate (resulting in eight to 28 missed days) and major (resulting in more than 28 missed days). Mediacoach video-tracking system collected time and external load variables and subsequently compared them between the pre-injury and return-to-play periods. The analyzed variables included distance covered at different velocities (i.e., total distance, at 18-21 km.h^{-1}, at 21-24 km.h^{-1}, and at more than 24 km.h^{-1}), the number of sprints, accelerations, decelerations, and high metabolic load distance (HMLD). The results showed that players with both the moderate and major injuries played fewer minutes after injury (p<.001 to p<.05) and experienced a decrease in maximum speed (p<.01 to p<.05), covering less total distance (p<.05) and exhibiting a decrease (p<.05) in average speed (only observed in players with major injuries). Additionally, moderately injured players experienced a reduction in the number of maximum accelerations (p<.05) and decelerations (p<.05), high metabolic load distance/min (p<.05), and average accelerations (p<.05). Furthermore, a significant reduction in the magnitude of maximum decelerations was observed in players with major injuries (p<.05). These findings highlight the importance of implementing strategies that enable the attainment of initial levels of high-intensity actions and maximum speed in reconditioning programs following hamstring injuries.

Key words: *physical conditioning, thigh muscles, external load, playing time, video tracking, return to play, football*

Introduction

Professional players must satisfy specific physical and physiological demands during soccer matches (Pons, et al., 2021). Among these demands, high-intensity actions such as jumps, sprints, and changes of direction are particularly noteworthy (Castillo, Raya-González, Weston, & Yanci, 2021), as they are closely associated with key performance-related actions (Faude, Koch, & Meyer, 2012). In order to optimize their readiness, soccer players must handle high volumes and intensities during training sessions, which, together with load fluctuations, could increase the injury risk (Gabbett, 2016). These injuries have a negative impact not only on the financial aspects of clubs but also on the teams themselves (Hägglund, et al., 2013), the performance of soccer players (Raya-González, et al., 2022), and their quality of life (Øiestad, Holm, & Risberg, 2018). Consequently, one of the main challenges for strength and conditioning soccer coaches is to reduce the injury risk faced by their athletes.

In professional male soccer, the overall incidence of injuries has been established in 8.1 injuries/1000 h of exposure, with a higher injury incidence in matches (36 injuries/1000 h of exposure) than in training sessions (3.7 injuries/1000 h of exposure) (López-Valenciano, et al., 2019). Specifically, injuries related to the hamstring muscle complex are the most common in soccer, with the biceps femoris being the hamstring muscle most frequently injured (Raya-González, de Ste Croix, Read, & Castillo, 2020). It has been demonstrated that male senior soccer players experience approximately 5-6 hamstring injuries per season (Ekstrand, Hägglund, & Waldén, 2011). This could be attributed to the specific architecture of the hamstring muscle complex, characterized by biarticular organization, dual innervations, and a specific fiber-type distribution (Ahmad, et al., 2013). Furthermore, the reported increase in high-speed running demands in soccer (Barnes, Archer, Hogg, Bush, & Bradley, 2014) appears to have a negative impact on the prevalence of hamstring injuries, as 70% of these injuries occur during high-speed running (Ekstrand, et al., 2012). It is possible that competitive performance, particularly in high-intensity actions, may be impaired after a hamstring injury, although studies on this topic are limited.

Specifically, Whiteley et al. (2022) found that players returning to football match-play after hamstring strain injury experienced reductions in high-speed match physical performance that were well within normal match-to-match variation in performance. Also, Jiménez-Rubio, Navandar, Rivilla-García, Paredes-Hernández, and Gómez-Ruano (2020) examined the impact of hamstring injuries on match performance parameters after the return to play (RTP). These researchers observed significant increases in maximum velocity, average velocity, work-to-rest ratio and distances covered at a high intensity (e.g., 19.8-25.1 km.h^{-1}) and sprint velocities (e.g., > 25.1 km.h^{-1}) after the injuries compared to initial values. However, it should be noted that all the players included in this study belonged to the same team and underwent the same reconditioning program after sustaining the same injury (i.e., grade IIb hamstring strain injury). Since each club follows its own reconditioning program and the schedule varies at the team level (e.g., a more congested schedule in high-level teams), it is necessary to conduct studies involving multiple teams. In this regard, a recent study conducted by Raya-González et al. (2022) analyzed the effects of injuries on playing time and performance parameters, although they considered injuries of all types. Given the close relationship between hamstring muscles and high-intensity actions, future studies focusing specifically on hamstring injuries are needed to optimize the return to play (RTP) process for such injuries.

To address the gap identified in the existing literature, this study recorded the external load before and after hamstring injuries in professional soccer players over the course of two competitive seasons. The main aim of this study was to analyze the impact of hamstring injuries on playing time and external load variables after the players' RTP process, considering the severity of the injury. We hypothesized that the players' match performance parameters would decrease in the initial matches following the injury, but would gradually improve over time, eventually reaching baseline levels after a certain number of matches.

Methods

Participants

The sample was composed of seventy-two hamstring injuries related to sixty-four professional soccer players who belonged to teams that competed in the First Division of the Spanish Professional soccer League (LaLiga™). These injuries were related to 81 match observations (i.e., five matches pre-injury and four matches after the return to play for each selected injury). Hamstring injuries were chosen according to the public information provided by the soccer club (i.e., official medical reports) (Raya-González, et al., 2022) and subject to the condition that the injured players participated at least in the matches mentioned above (i.e., five matches pre-injury and four matches after the return to play for at least 10 minutes). Due to their specific role, goalkeepers were excluded from the further analysis. LaLiga™ provided match external load data and authorization for their use in this study. The investigation was conducted according to the Declaration of Helsinki, ensuring players' and teams' confidentiality, and the protocol was approved by the ethics committee of the University of Extremadura (protocol number: 239/2019).

Study design and procedures

A retrospective, descriptive longitudinal design was applied to examine the changes in professional soccer players' match physical performance and their participation time after sustaining hamstring injuries, according to injury severity (i.e., moderate and major). The injury data from official medical reports for seasons 2018/2019 and 2019/2020 were obtained. This information was compared with the database provided by LaLiga™ (https://www.laliga.es/en), in which information about match physical performance and playing time was provided. The inclusion criterion for the statistical analysis was that the player who had suffered the hamstring injury participated in five matches pre-injury and four matches after the RTP for at least 10 minutes, so those injuries that did not fit the previously purposed inclusion criteria were excluded (Raya-González, et al., 2022). On this matter, mean values related to the five pre-injury matches were compared with those obtained in each post-injury match, differentiating between injuries according to severity. Match physical performance data were obtained using an optical tracking system ChyronHego® (TRACAB, New York, US). This multi-camera tracking system consists of eight super 4K-High Dynamic Range cameras based on a positioning system (Tracab - ChyronHego VTS) that film from several angles and analyze the X and Y positions of each player, thus providing real-time three-dimensional tracking. This instrument is also based on correcting the semi-automatic VTS (the manual part of the process). The validity and reliability of the Tracab® video-tracking system have been analyzed, reporting average measurement errors of 2% for the physical performance (Linke, Link & Lames, 2018; Pons, et al., 2021). In addition, recent studies have previously tested the agreement between the Mediacoach® system and GPS devices (Pons, et al., 2019). Specifically, the magnitude of the intraclass correlation coefficients (ICC) was higher than 0.90 (Pons, et al., 2019).

Injury definitions

The UEFA guidelines for epidemiological studies were used in this study (Hägglund, Waldén, Bahr & Ekstrand, 2005), so an injury was considered a "situation that occurred during a scheduled training session or match that caused absence from the next training session or match". Similarly, these guidelines were followed to differentiate the severity of injuries, classifying them into moderate (8-28 days of absence) and major (more than 28 days of absence). Slight and minor injuries were excluded. For each hamstring injury, the following information was registered: injury date, return to play date, missed days, severity, missed matches and match typology after the injury (Raya-González, et al., 2022).

Variables

The relative distance covered by the soccer players was recorded in $m.min^{-1}$ according to previous studies (Carling, 2013; Pons, et al., 2019): TD/min. (i.e., total distance covered by a player per minute); distance covered at intense running (i.e., distance covered between 18-21 $km.h^{-1}$ per minute); distance covered at high-speed running (i.e., distance covered between 21-24 $km.h^{-1}$ per minute); and sprinting (i.e., distance covered at more than 24 $km.h^{-1}$ per minute) (Pons, et al., 2021). The maximum and average speed ($km.h^{-1}$) reached by a soccer player in a match were also registered (Beato, et al., 2021). Likewise, the number of actions accelerating above 3 $m.s^{-2}$ and actions decelerating above -3 $m.s^{-2}$ performed by players per minute were analyzed. The mean and maximum values of accelerations and decelerations performed by a soccer player per minute in a match were also recorded (these values were recorded in $m.s^{-2}$). In addition, the high metabolic load distance covered per minute (HMLD/min) was registered (García-Calvo, et al., 2022). This variable refers to the distance covered with a power consumption above 25.5 $W.kg^{-1}$. Finally, each match's playing time was recorded, including five pre-injury matches and four matches after the return to play.

Statistical analysis

Statistical analyses were performed using R-studio. Linear mixed models (LMM) were applied to analyze the changes in match physical performances according to injury severity. LMM allows analyzing data with a hierarchical structure in nesting units and have demonstrated its ability to cope with unbalanced and repeated-measures data (Heck & Thomas, 2020). For example, distance covered in matches is nested for players across time (i.e., each player has a record for any match played). To determine the need to use this statistical procedure, we first calculated the levels of within-person variance for each player by constructing unconditional null models.

These unconditional models allowed us to calculate the intraclass correlation coefficient (ICC), which showed values greater than 10%, which indicated the existence of variability in the data and justified this analysis approach (Hox, Moerbeek & Van de Schoot, 2017). The playing time and match physical performances were included as dependent variables in the models, and injury severity was the independent variable included as a fixed effect. In this way, we compared the values of the players' variables in the five games before the injury with each of the following four games after the return to play. At the same time, the severity of the injuries and how they affected the next games were compared. This procedure involves including fixed and random effects in steps, progressing from the simplest to the most complex model. Model comparison for each step was made using the Akaike information criterion (AIC) (Akaike, 1973) and chi-square likelihood ratio tests (Field, 2017). A lower value of the AIC and the chi-square loglikelihood test indicated if the model was better than the previous one and if the changes were significant. The maximum likelihood (ML) estimation was employed to compare the models. Restricted maximum likelihood (REML) estimation was used for each final model (Field, 2017). The level of significance was set to 0.05.

Results

Table 1 presents the differences in variables related to playing time and distance covered between the pre- and post-injury matches by injury severity. In players with moderate injuries, significant differences were reported in playing time when pre-injury values were compared with + 1

Table 1. Differences in variables related to distance covered by soccer players between pre- and post-injury matches by injury severity

Variables		Minutes			**TD/min (m·min⁻¹)**			Intense running (m·min⁻¹)			**HSR (m·min⁻¹)**			Sprinting (m·min⁻¹)			Maximum speed (km·h⁻¹)			Average speed (km·h⁻¹)		
Injury severity		Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p
Moderate (n = 58)	Pre-injury	83.7 (2.52)	78.7, 88.7		111 (1.14)	108, 113		6.88 (.26)	6.37, 7.38		3.90 (.17)	3.56, 4.24		2.98 (.18)	2.62, 3.34		30.2 (.19)	29.8, 30.5		6.96 (.08)	6.81, 7.11	
	+1	69.1 (3.60)	62.0, 76.1	***	112 (1.34)	110, 115	.14	7.24 (.30)	6.66, 7.82	.08	3.93 (.20)	3.53, 4.33	.86	2.86 (.22)	2.42, 3.30	.49	29.6 (.25)	29.1, 30.1	*	7.05 (.09)	6.88, 7.22	.11
	+2	72.8 (3.50)	66.0, 79.7	**	110 (1.32)	108, 113	.73	7.09 (.29)	6.52, 7.67	.28	4.03 (.20)	3.64, 4.42	.38	3.05 (.22)	2.63, 3.48	.66	29.7 (.25)	29.2, 30.1	*	6.95 (.08)	6.78, 7.11	.76
	+3	78.1 (3.52)	71.2, 85.0	.11	110 (1.32)	107, 113	.47	6.81 (.29)	6.23, 7.39	.74	3.94 (.20)	3.55, 4.34	.79	3.11 (.22)	2.68, 3.54	.46	30.1 (.25)	29.6, 30.6	.72	6.93 (.09)	6.76, 7.10	.54
	+4	75.6 (3.45)	68.8, 82.3	*	111 (1.31)	108, 113	.83	7.10 (.29)	6.53, 7.67	.26	3.92 (.97)	3.53, 4.31	.91	2.90 (.22)	2.48, 3.33	.63	29.6 (.24)	29.1, 30.1	**	6.96 (.08)	6.79, 7.13	.98
Major (n = 14)	Pre-injury	82.0 (4.98)	72.2, 91.8		111 (1.94)	107, 115		6.81 (.43)	5.97, 7.65		3.90 (.29)	3.32, 4.48		3.05 (.32)	2.41, 3.69		30.5 (.36)	29.8, 31.2		6.94 (.12)	6.70, 7.18	
	+1	54.9 (7.34)	40.5, 69.3	***	109 (2.43)	104, 113	.26	6.71 (.53)	5.66, 7.75	.81	3.94 (.37)	3.21, 4.67	.88	2.92 (.42)	2.10, 3.74	.72	29.3 (.51)	28.4, 30.3	*	6.84 (.14)	6.55, 7.12	.35
	+2	82.0 (7.11)	68.0, 96.0	.99	111 (2.39)	107, 116	.83	6.42 (.52)	5.40, 7.45	.36	4.02 (.36)	3.30, 4.73	.70	2.65 (.41)	1.85, 3.46	.26	30.2 (.49)	29.2, 31.2	.57	6.93 (.14)	6.65, 7.21	.96
	+3	89.2 (7.60)	74.3, 104.1	.34	107 (2.49)	102, 112	*	6.16 (.54)	5.09, 7.22	.15	3.48 (.38)	2.73, 4.22	.19	2.73 (.43)	1.89, 3.57	.39	29.3 (.52)	28.3, 30.3	*	6.71 (.15)	6.42, 7.00	*
	+4	70.8 (7.11)	56.8, 84.7	.12	111 (2.39)	106, 115	.96	7.16 (.52)	6.14, 8.19	.40	3.97 (.36)	3.25, 4.68	.82	2.85 (.41)	2.04, 3.65	.56	29.7 (.50)	28.7, 30.7	.10	7.00 (.14)	6.72, 7.28	.54

Note. Coeff = coefficient; SE = standard error; CI = confidence interval; HSR = high-speed running; +1: first match after return to play; +2: second match after return to play; +3: third match after return to play; +4: fourth match after return to play; TD/min. = total distance per minute; intense running = distance covered between 18.0 and 21.0 km.h⁻¹; high speed running = distance covered between 21.0 and 24.0 km.h⁻¹; sprinting = distance covered above 24.0 km.h⁻¹; *p<.05, **p<.01, ***p<.001.

Table 2. Differences in variables related to mechanical performances by soccer players between pre- and post-injury matches by injury severity

Variables		Acc./min. (nº·min⁻¹)			Maximum accelerations (m/s²)			Average accelerations (m/s²)			Dec./min. (nº·min⁻¹)			Maximum decelerations (m/s²)			Average decelerations (m/s²)			HMLD/min. (m·min⁻¹)		
Injury severity		Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p	Coeff (SE)	95% CI	p
Moderate (n = 58)	Pre-injury	26.8 (.18)	26.4, 27.2		5.59 (.87)	5.42, 5.76		.55 (.01)	.53, .57		28.0 (.27)	27.5, 28.6		-6.03 (.08)	-6.18, -5.88		-.51 (.01)	-.53, -.49		24.6 (.60)	23.4, 25.8	
	+1	26.7 (.26)	26.2, 27.2	.79	5.50 (.15)	5.20, 5.80	.60	.57 (.01)	.55, .59	*	28.0 (.34)	27.3, 28.7	.90	-5.71 (.13)	-5.96, -5.46	*	-.52 (.01)	-.54, -.50	.06	25.5 (.68)	24.2, 26.9	*
	+2	27.1 (.25)	26.6, 27.6	.20	5.43 (.15)	5.14, 5.72	.33	.55 (.01)	.53, .57	.75	28.4 (.33)	27.8, 29.1	.15	-5.87 (.12)	-6.11, -5.63	.23	-.51 (.01)	-.53, -.49	.78	25.1 (.67)	23.8, 26.4	.23
	+3	26.9 (.25)	26.4, 27.4	.74	5.67 (.15)	5.38, 5.96	.62	.55 (.01)	.53, .56	.59	28.2 (.33)	27.5, 28.8	.67	-5.87 (.12)	-6.11, -5.63	0.24	-.51 (.01)	-.53, -.48	.65	24.4 (.67)	23.1, 25.7	.66
	+4	26.9 (.25)	26.4, 27.4	.59	5.25 (.14)	4.97, 5.53	*	.55 (.01)	.53, .57	.91	28.2 (.33)	27.6, 28.9	.49	-5.88 (.12)	-6.12, -5.65	.27	-.51 (.01)	-.53, -.49	.93	24.8 (.67)	23.5, 26.1	.57
Major (n = 14)	Pre-injury	26.5 (.36)	25.8, 27.2		5.40 (.18)	5.05, 5.76		.56 (.01)	.53, .59		27.9 (.49)	26.9, 28.8		-5.91 (.16)	-6.23, -5.60		-.51 (.02)	-.55, -.48		24.7 (.97)	22.8, 26.6	
	+1	26.9 (.53)	25.9, 27.9	.48	5.68 (.32)	5.06, 6.30	.44	.58 (.02)	.54, .61	.29	28.2 (.65)	26.9, 29.4	.59	-5.86 (.27)	-6.38, -5.34	.86	-.53 (.02)	-.57, -.49	.26	25.2 (1.17)	22.9, 27.5	.58
	+2	26.8 (.51)	25.8, 27.8	.62	5.38 (.30)	4.79, 5.98	.95	.56 (.02)	.52, .59	.93	28.1 (.63)	26.8, 29.3	.71	-6.53 (.26)	-7.04, -6.03	*	-.52 (.02)	-.56, -.48	.62	24.6 (1.15)	22.3, 26.8	.91
	+3	27.3 (.55)	26.3, 28.4	.14	6.01 (.33)	5.36, 6.66	.09	.55 (.02)	.52, .59	.64	28.7 (.66)	27.4, 30.0	.14	-6.00 (.28)	-6.54, -5.45	.78	-.50 (.02)	-.54, -.46	.41	23.2 (1.20)	20.9, 25.6	.13
	+4	26.6 (.51)	25.6, 27.6	.91	5.29 (.30)	4.69, 5.88	.74	.57 (.02)	.54, .60	.46	27.8 (.63)	26.6, 29.1	.99	-5.81 (.26)	-6.31, -5.31	.71	-.52 (.02)	-.56. -.49	.56	25.5 (1.15)	23.3, 27.8	.34

Note. Coeff = coefficient, SE = standard error; CI = confidence interval; +1: first match after return to play; +2: second match after return to play; +3: third match after return to play; +4: fourth match after return to play; Acc/min. =accelerations per minute; Dec./min. = decelerations per minute. HMLD/min. = high metabolic load distance per minute; *p<.05, **p<.01, ***p<.001.

(p<.001), + 2 (p<.01), and + 4 (p<.05) matches, while in players with major injuries only significant differences were observed when pre-injury values were compared with + 1 (p<.001) matches. Additionally, significant differences in moderate injuries were observed in maximum speed when pre-injury values were compared with + 1 (p<.05), + 2 (p<.05), and + 4 (p<.01) matches. Regarding major injuries, significant differences with pre-injury values were observed in TD (+3, p<.05), maximum speed (+1 and +3, p<.05) and average speed (+3, p<.05).

The differences in variables related to mechanical demands between pre- and post-injury matches by injury severity are presented in Table 2. In players with moderate injuries, significant differences from pre-injury values were observed in maximum accelerations (+4, p<.05), average accelerations (+1, p<.05), maximum decelerations (+1, p<.05) and HMLD/min (+1, p<.05), while in players with major injuries, only significant differences were observed when pre-injury values were compared with + 2 (p<.001) matches regarding the maximum decelerations variable.

Discussion and conclusions

This study analyzed the impact of hamstring injuries, classified by injury severity, on playing time and external load variables after the RTP in Spanish professional players. The main findings of this study show that players who suffered moderate and major hamstring injuries not only played fewer minutes during the RTP process but also showed a decrease in maximum speed, covered less total distance and had lower average speed (players with major injuries only). Additionally, moderately injured players experienced a decrease in maximum accelerations and decelerations, high metabolic load distance per minute (HMLD/min), and average accelerations. Players with major injuries also exhibited a reduction in the magnitude of maximum decelerations.

Our initial hypothesis was based on previous studies (Jiménez-Rubio, et al., 2020; Whiteley, et al., 2022) that highlighted the significant impact of hamstring injuries on external load variables, including speed, total distance, accelerations, and decelerations. It has been demonstrated that when athletes return to sports practice after suffering a hamstring injury, they exhibit a decrease in horizontal force production and a noticeable decline in sprinting speed performance (Mendiguchia, et al., 2014). This is due to the hamstring muscles play a crucial role in the initial contact phase of running, which is essential for generating hip extension and knee flexion power. Consequently, any impairment in these movements results in reduced forward force production as running speed increases (Belli, Kyröläinen & Komi, 2002). This impairment is further supported by hamstring strength deficits specifically in these joint movements, even when the soccer player has resumed regular training and competitions (Sanfilippo, Silder, Sherry, Tuite, & Heiderscheit, 2013). Besides, residual post-injury pain (Warren, Ingalls, Lowe, & Armstrong, 2002) and the potential fear and apprehension (Askling, Nilsson & Thorstensson, 2010) may be three alternative causes of loss in vertical force generation.

Furthermore, the biceps femoris and semitendinosus muscles are particularly susceptible to structural and functional injuries due to high-intensity accelerations and kicking actions. This susceptibility is attributed to the high biomechanical demands placed on the muscle-tendon unit (Askling, Tengvar, Saartok, & Thorstensson, 2007). Factors such as extensive stretching, eccentric overloading, and insufficient intermuscular coordination among the biceps, semitendinosus, and semimembranosus muscles contribute to hamstring injuries. Even during the return-to-play phase after a hamstring injury, full recovery of intermuscular coordination seems to be lacking in most cases, which may explain the observed reduction in maximum acceleration and deceleration performance (Sole, Milosavljevic Nicholson, & Sullivan, 2012). The spatial distribution of muscle work and the temporal activation characteristics of intermuscular interplay within the hamstrings are two critical factors that influence muscle load capacity and reduce vulnerability to injuries (Schuermans, Tiggelen, Danneels, & Witvrouw, 2014). This could elucidate why the injured participants in this study experienced a decrease in crucial accelerations and speed-related variables in the initial games after returning to play, as compared to subsequent matches.

In addition, hamstring injuries could affect certain technical and biomechanical features associated with optimal soccer performance. The decrease in speed observed in players who have had hamstring injuries may be attributed to inadequate sprinting technique (Røksund, et al., 2017). This could be a result of changes in hamstring muscle recruitment patterns, such as strength imbalances discussed earlier, or significant neuromuscular fatigue (Croisier, Ganteaume, Binet, Genty, & Ferret, 2008) and perceived exertion (Padulo, et al., 2017) due to the necessity of reconditioning and post-injury rehabilitation during the recovery phase. Furthermore, essential actions like the change of direction may be compromised during the return-to-play process, as high-speed accelerations and decelerations are required to perform optimally (Marshall, et al., 2014). It is for these reasons that a gradual return-to-play approach is often adopted, gradually increasing game time exposure. Despite not yet performing high-intensity actions to the required extent in the initial matches after returning to play, as demonstrated in this study, players are still exposed to sprints, accelerations, and decelerations as part of the reintegration process.

This study has certain limitations that should be taken into consideration when interpreting the results. The primary limitation is the lack of detailed information regarding the specific elements and factors of the injury rehabilitation process that may influence the physical and technical condition of the players, and consequently, their performance in external load variables. Additionally, it is important to note that the sample used in this study represents the injury reporting of professional soccer teams in a specific league, which may limit the generalizability of the findings to other populations or population subsets with different characteristics such as age, sex, ethnicity, technical abilities, among others. Finally, other contextual variables which could influence the obtained results, such as game times of the day, type of grass, temperature or humidity were not considered.

The results obtained from this study indicate that players who experienced hamstring injuries not only played fewer minutes during the return-to-play process but also exhibited a decrease in maximum speed (i.e., moderate and major injuries) and performed less total distance and average speed (specifically in players with major injuries). Additionally, moderately injured players experienced a decrease in maximum accelerations and decelerations, HMLD, and average accelerations. Players with major injuries also showed a reduction in the magnitude of maximum decelerations. These findings emphasize the significant impact of hamstring injuries on players' playing time and various external load variables. It underscores the importance of implementing appropriate strategies and programs to optimize the return-to-play process for individuals recovering from hamstring injuries.

From a practical standpoint, the findings of this study offer valuable insights for optimizing reconditioning programs for players suffering from hamstring injuries. The results emphasize the need to incorporate strategies that enable players to attain initial levels of high-intensity actions and maximum speed during the rehabilitation process. By focusing on these aspects, reconditioning programs can better prepare players to regain their pre-injury performance levels. This highlights the importance of tailoring rehabilitation protocols to target specific physical demands and performance parameters associated with hamstring injuries, ultimately aiding in the successful return to play and minimizing the risk of reinjury.

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Declaration of interest statement

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