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Injury inciting circumstances of sudden-onset hamstring injuries: video analyses of 63 match injuries in male professional football players in the Qatar Stars League (2013-2020)

Robin Vermeulen, MD[1,2], Nicol van Dyk, PT, PhD[1,3,4], Rodney Whiteley, PT, PhD[1], Karim Chamari, PhD[1,7], Warren Gregson, PhD[5,6], Lorenzo Lolli, PhD[5,6], Roald Bahr, MD[1,7], PhD, Johannes L Tol, MD, PhD[1,2], Andreas Serner, PT, PhD[1,8]

1. Aspetar, Orthopedic and Sports Medicine Hospital, Doha, Qatar
2. Amsterdam University Medical Centers, Academic Medical Center, Amsterdam, Academic Center for Evidence Based Sports Medicine, Amsterdam IOC Center, ACHSS, The Netherlands
3. School of Public Health, Physiotherapy and Sport Science, University College Dublin, Dublin, Ireland
4. Section Sports Medicine, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.
5. Aspire Academy, Football Performance & Science Department, Doha, Qatar.
6. Department of Sport and Exercise Sciences, Institute of Sport, Manchester Metropolitan University, UK.
7. Oslo Sports Trauma research Center, Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway
8. FIFA Medical, Fédération internationale de football association, Zurich, Switzerland.

Correspondence to:

Robin Vermeulen, MD

drrvermeulen@gmail.com

Abstract

Objective To describe and categorise the injury inciting circumstances of sudden-onset hamstring match injuries in professional football players using systematic video analysis.

Methods Using a prospective injury surveillance database, all sudden-onset hamstring match injuries in male football players (18 years and older) from the Qatar Stars League between September 2013 and August 2020 were reviewed and cross-referenced with broadcasted match footage. Videos with a clear observable painful event (i.e. a player grabbing their posterior thigh) were included. Nine investigators independently analysed all videos to describe and categorise injury inciting circumstances. We used three main categories: playing situation (e.g. time of injury), player action(s) (e.g. running), and other considerations (e.g. contact). Player action(s) and other considerations were not mutually exclusive.

Results We included 63 sudden-onset hamstring match injuries out of 295 registered injuries between 2013 and 2020. Running was involved in 86% of injuries. Hamstring injuries occurred primarily during acceleration of 0-10 m (24% of all injuries) and in general at different running distances (0 – 50 m) and speeds (slow to fast). At 0-10 m distance, indirect player-to-player contact and inadequate balance were involved in 53% and 67% of the cases, respectively. Pressing occurred in 46% of all injuries (injured player pressing opponent: 25%; being pressed by opponent: 21%) and frequently involved player-to-player contact (69% of the cases when the injured player was pressing versus 15% of the cases when the opponent was pressing) and inadequate balance (82% versus 50%, respectively). Other player actions that did not involve running (n=9, 14% of all injuries) were kicking (n=6) and jumping (n=3).

Conclusion The injury inciting circumstances of sudden-onset hamstring match injuries in football varied. The most common single player action (24%) was acceleration over a distance of <10 m. Pressing, inadequate balance, and indirect contact were frequently seen player actions. Injury prevention research in football should look beyond high-speed running as the leading risk factor for sudden-onset hamstring injuries.

Key words: Hamstring, injury, mechanism, video, prevention, rehabilitation

WHAT IS ALREADY KNOWN ON THIS TOPIC

- Hamstring muscle injury is the most common injury type in football.

- Sudden-onset hamstring injuries are reported to happen during high-speed running or stretching (hip flexion & knee extension).

WHAT THIS STUDY ADDS

- Sudden-onset hamstring injuries happen more frequently at lower speeds and distances than previously thought.
- Pressing, indirect contact, and inadequate balance are frequent factors involved in these injury situations.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- Research and application of prevention and rehabilitation strategies may need to consider injury mechanisms beyond high-speed running, especially short accelerations.
- The complexity of movements inherent in sport such as football is highlighted as a potential risk factor for injury.
- Introducing sport specific elements, such as playing situations, indirect contact, and unexpected changes to demands for performance may benefit injury prevention programmes in the future.

Introduction

Sudden-onset (acute) hamstring muscle injuries remain the most common type of injury in football and carry a high burden for the player and their team.[1–5] Historically, hamstring injury mechanisms have been grouped into two main categories; high-speed running and stretching (hip flexion & knee extension),[6] based on self-reporting/history taking, witnessing of the event, or on estimating the movement where the hamstring is at the highest risk of injury.[7] As a reflection of this, current prevention and rehabilitation strategies emphasise (return to) high-speed running capacity as a key focus from a functional perspective.[8–10] The effect of this emphasis remains unclear with sudden-onset hamstring injury rates continuing to rise.[11,12] Arguably, hamstring injury mechanisms beyond high-speed running should therefore also be considered.

Injury inciting circumstances in sport can be complex.[13,14] Video analysis has proven to be a useful tool in investigating this complexity. Three recent studies, utilising video analysis, examined the mechanisms of hamstring injury in cohorts comprised of 52 professional football players [15], 13 professional football players [16] and 17 professional rugby players [17]. The results indicate that the current classification may oversimplify our understanding of these injuries.[15–17] These studies used expert opinion to determine the moment of injury (assumed injury frame in the videos) and performed biomechanical analyses to describe injury kinematics.[15–17] Two studies (in football and rugby) reported that hamstring injuries seem to occur during various movements with rapid high eccentric demands, often characterized by hip or trunk flexion combined with active knee extension.[15,17] The other study (in football) reported a mixed-type injury mechanism: both sprint- and stretch-related.[16] Other reported injury mechanisms included sprinting, acceleration, deceleration, change of direction, kicking, rucking, and lunging.[15,17] In rugby, hamstring injuries most often appear to happen during running acceleration instead of maximal velocity running.[17] In football, this is also seen in 14/25 sprint-related cases.[15] This implies that injury mechanisms other than high-speed running might be more common than previously thought.

Using an assumed injury frame might provide biomechanical insights but also lacks a larger situational context. In-depth categorisation of the injury inciting circumstances and playing situations are not yet reported in football.[15] Therefore, our objective was to describe and categorise injury inciting circumstances: player actions, playing situation, and other considerations (e.g. contact) of sudden-onset hamstring injuries using systematic video analysis.

Methods

Study design and ethical considerations

This is a single centre observational cohort study. Using a prospective injury surveillance database, all sudden-onset hamstring match injuries in male football players from the Qatar Stars League were reviewed and cross-referenced with match footage. Ethics approval for this study was granted by the Aspire Zone Foundation Institutional Review Board (AZF IRB No: E202007003).

Population and recruitment criteria

Medical staff from each club recorded all types of injuries through the Aspetar Injury and Illness Surveillance Programme using a standardised injury card.[18] Information on the body part injured, injury type, onset of injury, questions related to re-injuries and the injury mechanism, occasion(training or a match) were included.[19] Using this database, we reviewed all sudden-onset hamstring match injuries that occurred in male professional football players (18 years and older) competing in the Qatar Stars League between September 2013 and August 2020. Players could also be identified through one of three sudden-onset hamstring injury studies that were previously conducted at the study centre but were never included twice.[9,20,21]. Full inclusion and exclusion criteria are listed in Box 1.

Injury definition

A hamstring injury was defined as "sudden-onset'' pain in the posterior thigh that occurred during training or match play and resulted in termination of play and inability to participate in the next training session or match."[22] Sudden-onset hamstring injuries were confirmed through clinical examination (identifying pain on palpation, pain with isometric contraction, and pain with muscle lengthening) by the club medical team.

Box 1: inclusion and exclusion criteria

Inclusion criteria

- Football player in the Qatar Stars League
- 18 years or older
- Male
- Registered sudden-onset hamstring injury in the Aspetar Injury and Illness Surveillance Programme database between 2013-2020 or registered in one the three study center hamstring studies from the same institution.

Exclusion criteria

- Injuries occurring during training.
- Injuries without available footage.
- Injuries that could not be identified on the video footage (no clear painful event).

Video acquisition, processing, and injury movement assessment

We accessed television-broadcasted video footage of the football matches through a local IPTV (Aspire Internet Protocol Television) access, using Wyscout, a digital database of football matches (Chiavari, Italy) or through STATSPERFORM (Stats LLC, Chicago, IL), a sports data and analytics platform. Using the prospective injury surveillance database, we cross-referenced the date of injury of players with a sudden-onset hamstring injury and the availability of video footage. If available, video footage was downloaded to a local server. Initially, three investigators (AS, RV, NVD) reviewed all videos (in separate batches) to determine the moment of injury. We included only injury situations with a clear painful event (i.e. the player grabbing their posterior thigh).

The video footage was subsequently edited with Windows Video Editor (Microsoft, Redmond, WA, USA) and viewed by all investigators in VLC media player (VideoLAN, Paris, France). To gain an impression of the playing situation, the video was cut from the last break in play prior to the injury, to the break in play immediately following injury. The edited video was in MPEG4 file format. It had a resolution of 1920:1080 and was encoded in a h.264 codec. Camera angles were varied throughout the videos and in some cases slow-motion was available.

Video analysis procedure

A standardised scoring form to assess the injury inciting circumstances was developed, critically reviewed, and tested by all nine investigators prior to scoring. This scoring form was developed using previous experience in video analysis of adductor longus injuries and a consensus framework on hamstring injuries in Rugby.[23,24] The investigators were from different backgrounds (three physiotherapists, three (sports medicine) doctors and three sports scientists). Scoring variables included: playing situation (pitch position, team action, type of play, injury situation), player actions (running (with subcategories: linear running, curved running, running speed and running distance), ball possession, change of direction, kicking, jumping, receiving the ball, reaching, heading, screening, blocking, and pressing) and other considerations (direct contact, indirect contact, type of contact and balance) (see supplementary table S1 for in-depth definitions). An initial impression of overall mechanism category (running, stretching or other type) was also scored in 'playing situation' to provide a simple categorization at a quick glance with reference to the previously reported hamstring injury mechanism categories [6]. Time of injury was scored separately by the main investigator based on timestamps of the match. In most cases, the scoring variables were not mutually exclusive and thus multiple variables could be scored for an injury situation. Injuries where only one player action could be determined were defined as 'single player action'. Injuries where multiple player actions could be determined were defined as 'multiple player actions'. All nine investigators were then given access to all videos containing the determined injury situation. They scored the videos independently, blinded to each other's scoring. Per variable, consensus was reached when a simple majority (at least five of the nine investigators) agreed on scoring. Any variable that did not reach consensus was discussed in online group meetings, where videos were viewed again to see if consensus could be reached. Scoring was recorded using Excel (Microsoft®, Redmond, WA, USA).

Data analysis

Descriptive data were analysed using SPSS (version 26.0, IBM®, New York, United States). Classification tree analysis was used to explore and identify player actions that were commonly involved with each other. Classification tree analysis is a method used to categorise things based on specific attributes or characteristics they possess (in our case, player actions). It's similar to sorting items into distinct groups using their properties. This classification tree analysis was performed in Orange (Bioinformatics Lab at University of Ljubljana, Slovenia).[25]

Equity, diversity, and inclusion statement

Our study population consisted of players from different socioeconomic and ethnic backgrounds in the male professional football league in Qatar. Author disciplines include sports science, physiotherapy, and medicine, and include four early career researchers.

Results

A total of 295 sudden-onset hamstring match injuries were registered during the study period. Video footage was available for 131 injuries, and in 63 videos we identified a clear painful event consistent with the recorded hamstring injury (see figure 1). No additional players were identified through the other three hamstring injury studies conducted at the study centre.

Player demographic information

The age of the players was 28.5 (± 3.8) years (mean (SD), height 177 (± 5.6) cm, and body mass 74 (± 9.5) kg. Playing positions were: goalkeeper (n=2), defender (n=21), midfielder (n=21) and forward (n=19). Five players had partially missing demographic data (missing: body-mass n=3, height n=1, height and body-mass n=1).

Scoring consensus

We scored 1227 items in 63 videos. Of these, 142 (12%) items needed additional discussions to reach consensus. The assessment of subcategories in the 'balance' item often did not have agreement. It was therefore decided to change the balance subcategories to only 'adequate' or 'inadequate' (as an aggregate of the original subcategories), during the subsequent consensus discussions.

Injury inciting circumstances

28 (44%) injuries occurred in the first half and 35 (56%) in the second half of the match (table 1). Injuries happened in different areas of the pitch, with 41% in the mid-field (mid-third own side and opponent side) and nearly all occurred in play (Table 1). There was no difference in team action at the moment of injury (defensive 52% vs offensive 48%) (Table 1).

Table 1: Description of the playing situation when the injury occurred in 63 sudden-onset hamstring injuries

Time of injury (min)	0 – 15	10	16%
	16 – 30	10	16%
	31 – 45	8	13%
	45+ (extra time)	0	0%
	46 – 60	14	22%
	61 – 75	5	8%
	76 – 90	13	20%
	90+ (extra time)	3	5%
Pitch position: end of pitch	Own third	21	33%
	Mid third (own side)	13	21%
	Mid third (opponent side)	13	21%
	Opponent third	16	25%
	Unclear	0	0%
Pitch position: side of pitch	Right	18	29%
	Left	18	29%
	Central	27	43%
	Unclear	0	0%
Team action	Defensive	33	52%
	Offensive	30	48%
	Free ball (no possession)	0	0%
	Unclear	0	0%

Type of play	In play	59	94%
	Set play	4	6%
	Unclear	0	0%
Injury situation	Clear player action(s)	52	83%
	Unclear player action(s)	11	17%
Initial impression of category (n = 62, 1 missing)	Running type	43	68%
	Stretching type	9	14%
	Other	10	16%

Player actions

A single player action was observed in 44 (70%) injuries, whereas multiple player actions were observed in 19 (30%) injuries. An overview of all player actions can be found in Table 2. Specific single player actions and multiple player actions can be found in Tables S1 and S2 in the supplementary files. Figure 2 illustrates diverse instances of sudden-onset hamstring injuries, providing a visual representation for understanding the injury inciting circumstances and playing situations.

Running as an action was part of most injury situations (86% of all injuries). It was a single player action in 35 injuries (56% of all injuries, 80% of injuries with a single player action) and combined with other player actions in 19 injuries (30% of all injuries, 100% of injuries with multiple player actions). Kicking (with varying kicking types) accounted for two thirds of the injuries not involving running (6/9) and jumping for one third (3/9). Change of direction only occurred as a part of multiple player actions (14% of all injuries).

Table 2: Player action(s) in 63 sudden-onset hamstring injuries

		n	% of category	% of all injuries
Running (linear) (n = 41, 66%)	Acceleration	24	59%	38%
	At speed	10	24%	16%
	Deceleration	2	5%	3%
	Unclear	5	12%	8%
Running (curved) (n = 13, 21%)	Acceleration	7	54%	11%
	At speed	2	15%	3%
	Deceleration	2	15%	3%
	Unclear	2	15%	3%
	Turning from injured leg	6	46%	10%
	Turning toward injured leg	7	54%	11%
	Unclear	0	0%	0%
Running speed	Fast	18	33%	29%

(n = 54, 86%)	Moderate	33	61%	52%
	Slow	2	4%	3%
	Unclear	1	2%	2%
Running distance (in meters) (n = 54, 86%)	0-10 m	24	44%	38%
	10-20 m	8	15%	13%
	20-30 m	14	26%	22%
	30-40 m	5	9%	8%
	40-50 m	2	4%	3%
	>50 m	1	2%	2%
Ball possession (n = 54, 86%)	Injured player running with ball	16	30%	25%
	Injured player running without ball	38	70%	60%
Change of direction (n = 9, 14%)	Angle:			
	0 - 45 degrees	2	22%	3%
	45 - 90 degrees	5	56%	8%
	>90 degrees	1	11%	2%
	Unclear	1	11%	2%
	Type:			
	Side-step	4	45%	6%
	Crossover	3	33%	5%
	Split step	0	0%	0%
	Other	1	11%	2%
	Unclear	1	11%	2%
	Direction:			
	Towards injured leg	3	33%	5%
	Away from injured leg	6	67%	10%
	Unclear	0	0%	0%
Kicking (n = 13, 21%)	Leg:			
	Kicking leg	10	77%	16%
	Supporting leg	3	23%	5%
	Unclear	0	0%	0%
	Type of kick:			
	Pass	7	54%	11%
	Long pass	1	8%	2%
	Cross	2	15%	3%
	Shot on goal	1	8%	2%
	Clearing	2	15%	3%
	Unclear	0	0%	0%
	Direction:			

	Forwards	5	39%	8%
	Backwards	2	15%	3%
	To the side	3	23%	5%
	Diagonal	2	15%	3%
	Unclear	1	8%	2%
	Ball impact:			
	Side-foot	5	39%	8%
	Instep	3	23%	5%
	Toe kick	1	8%	2%
	Heel kick	2	15%	3%
	Volley	1	8%	2%
	Half-volley	0	0%	0%
	Unclear	1	8%	2%
Jumping (n = 7, 11%)	Take-off phase leg:			
	Injured leg	1	14%	2%
	Uninjured leg	3	43%	5%
	Both legs	3	43%	5%
	Unclear	0	0%	0%
	Landing phase leg:			
	Injured leg	3	43%	5%
	Uninjured leg	3	43%	5%
	Both legs	0	0%	0%
	Unclear	1	14%	2%
	Landing position:			
	Good	1	14%	2%
	Bad	4	57%	6%
	Fall	1	14%	2%
	Unclear	1	14%	2%
Receiving the ball (n = 10, 16%)	With injured leg	5	8%	8%
	With uninjured leg	3	5%	5%
	Other	2	3%	3%
	No receiving	53	84%	84%
	Unclear	0	0%	0%
Reaching (n = 11, 17%)	With injured leg	8	13%	13%
	With uninjured leg	3	5%	5%
	No reaching	52	83%	83%
	Unclear	0	0%	0%
Heading (n = 3, 5%)	Heading	3	5%	5%
	No heading	60	95%	95%

	Unclear	0	0%	0%
Screening (n = 0)	Screening for teammate	0	0%	0%
	Being screened by opponent	0	0%	0%
	No screening	63	100%	100%
	Unclear	0	0%	0%
Blocking (n = 1, 2%)	Blocking ball from opponent	1	2%	2%
	No blocking	62	98%	98%
Pressing (n = 29, 46%)	Pressing opponent	16	25%	25%
	Pressed by opponent	13	21%	21%
	No pressing	34	54%	54%
	Unclear	0	0%	0%

Linear and curved running

Hamstring injuries during linear running occurred during acceleration at 0-10 m (n=15, 24% of all injuries), and at different running distances and running speeds (see figure 3, table 2). Player-to-player contact and inadequate balance were frequently involved (53% and 67%, respectively) in short-range acceleration type injuries. Moderate to fast 'at speed' running of 20 m or more occurred in 10 injuries (16% of all injuries), with player-to-player contact or inadequate balance not frequently involved.

Hamstring injuries during curved running also occurred at different distances and running speeds. Curved running deceleration was seen in two cases (3% of all injuries). Both deceleration injuries had an overstep or overstride component. Linear running deceleration was also seen in two cases (3% of all injuries), and one had an overstep component.

Pressing

Pressing was seen with player-to-player contact. In injuries without pressing, there was also no contact 88% of the time. Contact was seen in 12% of injuries without pressing and the type of contact was 'unintentional' in all cases.

The injured player intending to intercept the ball was seen in 25% of all injuries. Contact was seen in 69% of these situations and balance was inadequate in 82% of the time.

The opponent intending to intercept the ball was seen in 21% of all injuries. Contact was seen in 15% of these situations and balance was inadequate 50% of the time. See also figure S1 and table S3 in the supplementary file.

Pressing occurred relatively more frequently during multiple player actions than as a single player action (86% versus 36%).

Table 3: Other considerations

Contact[15] (n = 62, 1 unclear)	No contact	45	73%
	Direct contact	0	0%
	Indirect contact:	17	27%
	- Intentional contact by injured player	7	11%
	- Intentional contact by opponent	2	3%
	- Unintentional contact	8	13%
	Type of indirect contact:		
	Sliding tackle	1	6%
	Shoulder tackle	3	17%
	Collision	3	17%
	Push (with arms)	4	22%
	Other	5	28%
	Unclear	2	11%
Balance (n = 63)	Adequate	37	59%
	Inadequate	26	41%

Discussion

In this video-analysis study, 63 sudden-onset hamstring injuries in professional football match-play were analysed. Our primary finding was that one in four hamstring injuries occurred during acceleration at short distances (0 to 10 m). Player pressure (on the opponent or by the opponent), inadequate balance, and indirect contact moments were also factors involved with many of the injuries.

Running-type injuries

Acceleration type hamstring injuries over distances of 0 to 10 m (24%) occurred one-and-a-half times more often than a 'typical' (16%) sprinting hamstring injuries (i.e. high-speed running over a longer distance).[6] Acceleration was also found to be a frequent action in a recent video analysis study in professional football.[15] However, the ratio of acceleration versus high-speed running injuries was nearly equal and no distances were described.[15] In another recent video analysis study in professional football, it was reported that horizontal speeds were classified as 'very high (sprinting)' in 43% of cases and 'moderate to high (high-intensity running below sprinting)' in 36% of the total 14 cases.[16] In rugby, acceleration has been found to occur in 67% of the hamstring injuries involving running.[17] Distances were also not reported in the rugby study. Deceleration was a new, but minor factor reported for hamstring injuries in rugby.[17] We also found that a minority of sudden-onset hamstring injuries occurred during deceleration, frequently involving an overstep/overstride. The trend in the literature that high-speed running exposure could reduce hamstring injury risk is supported by evidence of an exponential increase in workload of the hamstrings at higher speeds.[26–29] In light of the current evidence, injury prevention and rehabilitation should likely not be focused solely on high-speed running, but rather on increasing a player's capacity to handle different situations, including shorter distance accelerations with a pressing component (with and without indirect contact). Small-sided games is a frequently used training format covering these types of situations, but direct evidence related to injury prevention is lacking.[30]

Factors during running

Contact with another player, inadequate balance and/or pressing were most frequently seen during running at short distances. Fast running at higher distances also frequently displayed inadequate balance at the suspected moment of injury. Contact with another player was a less frequent factor here compared with short runs.

In our study, there was no direct contact seen, unlike the 20 direct contact injuries reported by Gronwald et al, although they excluded these injuries.[15] Indirect contact was involved in 33% of all hamstring injuries, compared to 27% in our study. In contrast, only 12% of the sprinting injuries in their study involved indirect contact, compared to 30% of the running injuries in our study. Indirect contact hamstring injuries are rarely described in the literature, where non-contact (strain) injuries or direct contact (contusion) injuries are more common.[31–33] In our study, 40% of the running injuries that occurred within 10 m involved indirect contact. These differences may be explained by playing positions, though a direct comparison could not be made as data were not reported.[15]

Change of direction was another factor seen during running albeit less frequently. Change of direction happened mostly while turning away from the injured side (67%), similar to the change of direction injuries described by Kerin et al. (100%).[17] Change of direction occurred in 41% of their injuries versus 14% in our cohort. This is likely due to difference in sports or the relatively low sample size in their study.[17] The involvement of change of direction in sudden-onset hamstring injuries is rarely described, being more common in groin injuries and anterior cruciate ligament injuries.[34,35]

Lastly, reaching with the injured leg was seen in 13% (8) of all injuries and only during running. However, there was no direct connection seen with other player actions besides running in general (i.e. various speeds and types of running), making it hard to discern a pattern. In contrast, Gronwald et al have seen a lunging pattern (similar to reaching) in 31% (16) of their injuries and Jokela et al described only one injury (7% of their injuries) as reaching.[15,16]

Injuries that did not involve running

Sudden-onset hamstring injuries that did not involve running were a minority in our study, occurring in only 14% of all injuries. Kicking accounted for 67% of these (10% of all injuries) compared to the 15% of all hamstring injuries reported by Gronwald et al.[15] Another similar incidence of kicking injuries (11%) was seen in a recent rehabilitation study (with mostly football players).[9] Kicking is also a reported player action for sudden-onset hamstring injuries in other sports, accounting for 10-19% of sudden-onset hamstring injuries in Australian rules football and English rugby union.[9,36] Lastly, reaching with the injured leg as a single player action was seen in only 6% of all injuries.

Research implications

Given the above findings, it seems that injuries involving short runs (with contact and inadequate balance) and injuries involving change of direction might be largely underreported hamstring injury situations. Kicking appears to consistently account for a smaller proportion of injuries (around 1 in 10 injuries)[9,36] and may therefore also need to be considered in preventative efforts. In the often time constrained environment of prevention and rehabilitation it is key to select the most appropriate intervention(s). Superiority of utilising interventions specifically focusing on prevention of sprinting type injuries or kicking type injuries or utilising a multifactorial approach is still debated.[8,37] Hamstring strengthening exercise may represent a valuable approach to mitigate hamstring injury risk, yet the effects of adding interventions incorporating the varied player actions deserve further clinical investigation.[3,38–41]

Limitations

One of the main limitations of video studies is that it is impossible to determine when a sudden-onset hamstring injury happens exactly. Although we used a clear painful event combined with injury surveillance data, actions leading up to injury were still determined by opinion of the analysts. Furthermore, no formal rater reliability testing was performed.

Injury reporting forms were constructed based on similar previous studies.[24] Video quality and angles may have influenced scoring; however, this was unavoidable as video data was from a third party and consisted of broadcasted footage only. This study only included male professional football players, therefore generalisability to female players, different levels, age groups, and other sports is uncertain.

In this study, we analysed 63 clear sudden-onset hamstring injuries. However, this is only 48% of the diagnosed injuries which had an available video. The remaining injuries could not be clearly identified on the video and may be a result of these players continuing to play despite pain, which subsequently caused time-loss. Minor hamstring pain or ‘niggles’ could be a considerable contributor to diminished training and/or match availability,[42] and their mechanisms may be different than those reported here.

Lastly, our video analysis procedure was a synthesis of available evidence. However, our framework was largely based on a video analysis consensus study in rugby. This underpins the fact that a similar consensus for hamstring injuries in football is yet to be conducted. A consensus on a standardised system to classify injury-inciting circumstances for any injury in football was published after this study was conducted.[14] There are therefore differences in our analyses approach, which will limit future comparisons.

Conclusion

Sudden-onset hamstring injuries in professional football happened at varying running phases, speeds, and distances, but the most common single player action (one in four injuries) was acceleration over a distance of <10 m. Pressing, inadequate balance, and indirect contact were frequently involved. Injury prevention (research) in football should look beyond high-speed running as a causal factor for sudden-onset hamstring injuries.

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Figure legends:

Figure 1: Flowchart of injury and video identification.

Figure 2: examples of sudden-onset hamstring injuries and the identification of injury inciting circumstances. a.1: injured player (blue dot) defending attacking player (orange dot). Running directions are illustrated by blue and orange arrows, a.2: attacking player repositions to attempt shot on goal, injured player accelerates to follow. a.3 attacking player attempts to score (ball trajectory dotted blue line) and injured player attempts to intercept ball with right leg. a.4 injured player immediately goes down after attempt to intercept ball (hamstring injury right leg). b.1 injured player (orange dot) accelerates (direction orange arrow) to receive cross from teammate (ball trajectory dotted blue line). b.2 after receiving ball injured player is pressed by opponent (blue dot) and kicks ball forward with right foot (ball trajectory dotted blue line) b.3 immediately after kicking ball forward, injured player loses balance and stumbles forward on left leg and sustains injury. b.4 injured player walking off whilst grabbing left posterior thigh. c.1 opponent (orange dot) receives ball from teammate (off-screen) and lets it pass through his legs. Injured player (blue dot) is pressing. c.2 injured player accelerates and changes direction (first time) c.3 injured player is still accelerating and changes direction (second time), grabs opponent c.4 injured player goes down with hamstring injury (right leg) after second change of direction. d.1 injured player (orange dot) getting pressed by opponent (blue dot), prepares to a backward pass ('heelie') with right leg. d.2 injured player makes contact with ball d.3 injured player immediately sustains injury after backwards pass and grabs right posterior thigh. (Images from figure 2 are owned by Alkass Sports Channels and were accessed through a local IPTV (Aspire Internet Protocol Television) access).

Figure 3: Exploratory classification tree in 41 linear running injuries (out of 63 sudden-onset match hamstring injuries).