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What is This?

The Diagnostic and Prognostic Value of Ultrasonography in Soccer Players With Acute Hamstring Injuries

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Background: An injury to the hamstring muscle complex is the most common injury in soccer. Ultrasound of acute hamstring injuries is often used as a clinical tool for diagnosing hamstring injuries and guiding players in when they can return to play.

Purpose: To (1) investigate the characteristic sonographic findings of acute hamstring injuries in soccer players, (2) compare the mean injury severity (time to return to play) in injured players with and without sonographically verified abnormalities, and (3) correlate the length of the injured area and absence from soccer play (time to return to play) to investigate if ultrasonography can be used as a prognostic indicator of time to return to play.

Study Design: Case series; Level of evidence, 4.

Methods: Players from 50 teams participating in 1 of the top 5 Danish soccer divisions were followed in the period from January to December 2008. Of 67 players with acute hamstring injuries, 51 underwent ultrasonographic examination of the injured thigh and were included in this study.

Results: Ultrasonographic examinations were performed 1 to 10 days after injury (mean, 5.2 ± 3.0 days), and sonographic findings were present in 31 of 51 cases (61%). Two thirds of the injuries were to the biceps femoris muscle and one third to the semitendinosus muscle. No total ruptures were documented. The 51 acute hamstring injuries resulted in absence from soccer of a mean 25.4 ± 15.7 days per injury, with no significant difference between players with and without sonographically verified abnormalities (P = .41). No correlation existed between the length of the injured area and injury severity (r = 0.19, P = .29).

Conclusion: The biceps femoris is the most commonly injured hamstring muscle detected by ultrasound, and more than half of the injuries are intramuscular. Because neither the presence of sonographic findings nor the size of the findings was correlated with time to return to play in injured soccer players, the prognosis of hamstring injuries should not be guided by these findings alone.

Keywords: hamstring; injury; sonography; ultrasonography; soccer; football

Football/soccer is the most popular sport worldwide, with approximately 265 million active players.[12] It has been documented that the most common injury in adult male soccer players is a hamstring injury, which in elite soccer accounts for 12% to 16% of the total number of injuries.[1,10,25,31] Until the 2000s, only a small number of acute hamstring injuries were examined using an imaging technique.[31] However, the accessibility and reduced cost of ultrasonography have in recent years resulted in a significant increase in the use of musculoskeletal imaging, and a further increase is predicted in the years to come.[23] As a consequence of this, an increasing number of soccer players with hamstring injuries will be examined using ultrasonography, which is accessible in most elite and subelite clubs. Hence, it is important to document expected pathological findings and the clinical values of these.

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Several studies conducted on athletes within Australian rules football (ARF),[8,14,27,29] American football,[7] football/soccer,[11] and athletics[2] have documented moderate to strong correlations between various magnetic resonance imaging (MRI) findings, including the length of injury, after acute hamstring injuries and time to return to competition. The accessibility of acute MRI is often limited, and this imaging modality is expensive, which restricts the practical use of MRI. Connell et al,[8] in a study including 60 professional male ARF players with acute hamstring injuries, concluded that MRI and sonography are equally useful for identifying acute hamstring injuries. Therefore, because of the easier accessibility and lower costs of ultrasonography compared with MRI, it would be of clinical relevance to investigate whether sonographic findings after acute hamstring injuries are related to time to return to play. This issue has only been investigated in the Connell et al[8] study, which found that multivariate analyses identified a model associated with delayed recovery. This model included the presence of an injury to the biceps femoris muscle, the cross-sectional area of the injury, and the presence of intermuscular hematoma. However, as discussed by Ekstrand and coworkers,[11] caution should be employed when transferring knowledge from one sport to another. Thus, it is unknown but would be of clinical importance if the relationship between time to return to play and sonographic findings also could be established in soccer, as a hamstring injury is the most frequent injury in this sport among male adult elite athletes, and clinical tools are lacking in relation to understanding the injury, the high rates of reinjury, and the injury's general recovery time.[30] Therefore, the aims of this study were to

1. investigate the characteristic sonographic findings of acute hamstring injuries in soccer players,
2. compare the time to return to play in injured players with and without sonographically verified abnormalities, and
3. correlate the length of the injured area and time to return to play to investigate if ultrasonography can be used as a supplement to the clinical examination in estimating the prognosis of time to return to play.

MATERIALS AND METHODS

Recruitment of Participants

Fifty soccer teams playing in the top 5 Danish soccer divisions participated in an intervention study regarding the prevention of hamstring injuries.[24] A total of 942 players on the first team squad of these teams were all offered a free ultrasound examination in case of sustaining an acute hamstring injury that fulfilled the injury definition. Baseline data and written consent from all players were obtained before study initiation.

Of the 67 players who sustained an acute hamstring injury, 51 underwent an ultrasound examination of the injured thigh and were included in the study. Eight of the 51 participants were categorized as national elite players (competing at the best or second-best national competition level), whereas the remaining 43 players were categorized as subelite (competing at the third- to fifth-best competition level). Figure 1 shows the trial profile.

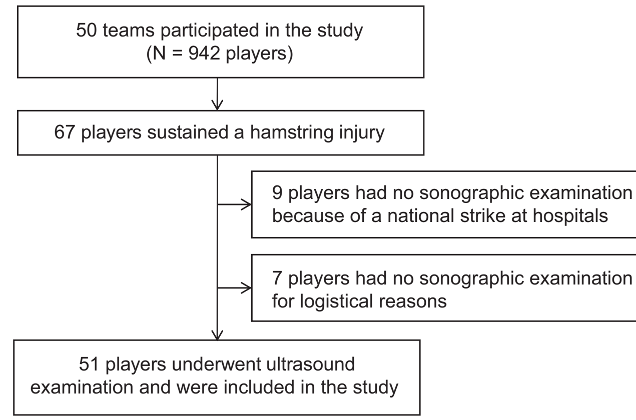

Figure 1. Trial profile.

Sixty-seven players sustained an acute hamstring injury. Because of a national strike at hospitals from April 16, 2008 until June 15, 2008, it was not possible to conduct sonographic examinations of patients included in scientific projects at 2 of the 3 hospitals affiliated with this study within that period. Therefore, 9 players who were injured in that period did not undergo a sonographic examination. Further, 7 players were not examined because of logistical reasons. No difference regarding age or competition level existed between the remaining 51 players who underwent a sonographic examination and the 16 players who were not examined sonographically.

The local ethics committee approved the trial protocol (H-A-2007-0062), which was registered with the National Data Protection Agency (2007-41-0275) and with ClinicalTrials.gov (NCT00557050).

Sonography

Ultrasound examinations were performed 1 to 10 days after injury (mean, 5.2 ± 3.0 days) in the period from January to December 2008. Four radiologists, all with more than 10 years' experience in musculoskeletal sonography, performed the ultrasound examinations. A high-frequency linear array transducer was used, and a standardized protocol in accordance with Connell et al[8] specifying the position of the player and the approach was followed (Table 1).

Edema and hemorrhaging were diagnosed on the basis of the presence of an area of increased echogenicity with or without muscle fiber disruption visible in orthogonal planes. Consequently, an injury represents a combination of a fiber rupture, hemorrhage, and/or edema, and the longitudinal length, expressed in millimeters, was measured using the calibrated measurement tool within the ultrasound machine.

Definitions

In accordance with the general injury definition by the Fédération Internationale de Football Association

TABLE 1
Standardized Protocol Used When Performing Ultrasound Examinations

- Position the player prone on a table without the feet touching the table (to ensure 0° of flexion in the hip and knee joints)
- Scan the biceps femoris, semitendinosus, and semimembranosus muscles longitudinal and transversal from their origin at the ischial tuberosity to their insertion at the knee joint
- Note the name of the injured muscle(s)
- Note the injury site(s) (tendon, muscle, musculotendinous junction)
- Note the length of the injured area (in mm)
- Note the presence of calcification (myositis ossificans)

(FIFA),[13] a hamstring injury was defined as the following: any suddenly occurring physical complaint in the region of the posterior thigh sustained during a soccer match or training, irrespective of the need for medical attention or time loss from football (soccer) activities. Hence, overuse injuries were not included. Further, injuries due to direct trauma (contusions) were excluded. The medical staff, in consultation with the player, decided when the injured patient could return to play, which was defined as availability for match selection or full participation in team training if the injury occurred during a period without match play. An overview of the general definitions is presented in Table 2.

Statistical Analysis

Data were entered into an Excel 2007 spreadsheet (Microsoft Corp, Redmond, Washington, USA) and were analyzed with SPSS software version 17.0 (SPSS Inc, Chicago, Illinois, USA). Descriptive statistics are presented as the number (%) or mean ± standard deviation. An independent-samples *t* test was used to determine statistical significance within group differences. The number of days that elapsed from the date of injury (day zero) to the date of the player's return to play was correlated (linear dependence) with the length of the injured area identified on sonography and expressed as a Pearson correlation coefficient (r). The level of significance was set at $P < .05$.

RESULTS

A rupture, hematoma, and/or edema were present either as a single finding or in combination in 31 of the 51 cases (61%). Myositis ossificans was not present in any cases. The biceps femoris was the most commonly injured muscle (58% of the detectable injuries). Characteristics of the injured players are presented in Table 3, and characteristics of the 31 sonographically verified hamstring injuries are shown in Table 4. An example of an ultrasound-verified hamstring injury is shown in Figure 2.

The 51 acute hamstring injuries resulted in 6 to 74 days of absence from injury to return to play (mean, 25.4 ± 15.7 days). The mean time to return to play in players without sonographically verified abnormalities was 23.7 ± 16.4 days, whereas the corresponding time in players with verified abnormalities was 27.5 ± 15.2 days. This difference was not statistically significant ($P = .41$).

The lengths of sonographically verified injuries were 4 to 40 mm (mean, 20.3 ± 9.3 mm). No correlation existed between the length of the injured area and time to return to play ($r = 0.19$, $P = .29$).

TABLE 2
Definitions

Term	Definition
Training	Team-based and individual physical activities under the control or guidance of the team's coaching or fitness staff that are aimed at maintaining or improving players' soccer skills or physical condition
Match	Play between teams from different clubs
Hamstring injury	Any suddenly occurring physical complaint in the region of the posterior thigh sustained during a soccer match or training, irrespective of the need for medical attention or time loss from soccer activities
Overuse injury	Injury with insidious onset and no known trauma
Contusion	Injury due to direct (blunt) trauma
Rehabilitation	A player was considered injured until the team's medical staff allowed full participation in training and availability for match selection
Time to return to play	Number of days from injury to the end of rehabilitation

TABLE 3
Characteristics of Injured Players (n = 51)[a]

Characteristic	Value
Age, mean ± SD, y	24.2 ± 3.4
Height, mean ± SD, cm	181.8 ± 5.4
Weight, mean ± SD, kg	77.6 ± 6.9
Dominant leg injured	28 (54.9)
Previous hamstring injury[b]	9 (17.6)
Position	
Goalkeeper	1 (2.0)
Defender	18 (35.3)
Midfielder	16 (31.4)
Forward	10 (19.6)
Alternating	6 (11.8)

[a]Data are expressed as n (%) unless otherwise indicated.
[b]Within 1 year before the trial.

DISCUSSION

This is the first study documenting the sonographic findings concerning acute hamstring injuries in soccer players. The main findings of the study are that ultrasonography was able to detect abnormalities in 61% of players with acute hamstring injuries, but no difference regarding the time to return to play was documented in players with or

TABLE 4
Location and Characteristics of Hamstring Injuries With Sonographically Confirmed Abnormalities (n = 31)[a]

Muscle Injured	Total	Location		
		Proximal MTJ	Distal MTJ	Intramuscular[b]
Biceps femoris	18 (58)	6 (33)	2 (11)	10 (56)
Semitendinosus	9 (29)	0	0	9 (100)
Semimembranosus	0	—	—	—
Not possible to determine	4 (13)	—	—	4 (100)

[a]Data are expressed as n (%). MTJ, musculotendinous junction.
[b]Whether these injuries were adjacent to or separated from the intramuscular tendon was not examined.

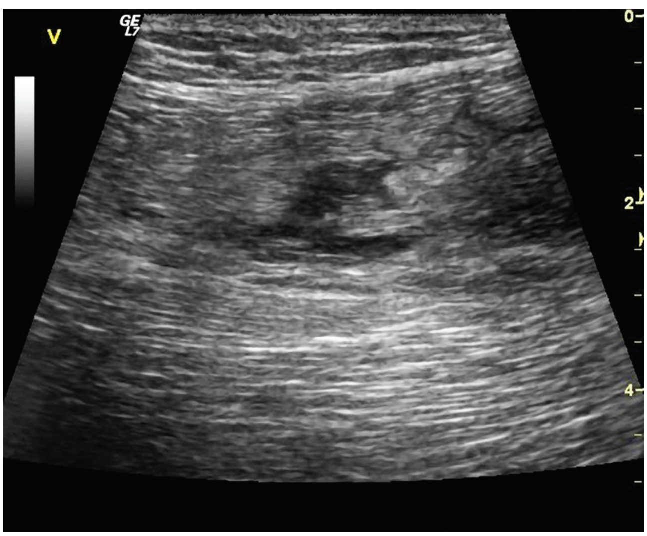

Figure 2. Example of injury.

without sonographically detected abnormalities. Further, no correlation exists between sonographic findings (length of the injury) and time to return to play.

Sonographically detectable abnormalities were present in 61% of the acute hamstring injuries (31 of 51 cases). Approximately two thirds of the injuries were localized to the biceps femoris muscle, whereas one third were to the semitendinosus muscle. No injuries were localized to the semimembranosus muscle. This injury distribution, with a majority of injuries to the biceps femoris muscle, is consistent with findings in studies using MRI.[8,14,17,29] Most injuries to the biceps femoris muscle were localized within the muscle and a considerable number at the proximal free musculotendinous junction. Only 2 injuries were localized at the distal free musculotendinous junction. All 9 injuries to the semitendinosus muscle were localized within the muscle. Whether these injuries were adjacent to or separated from the intramuscular tendon was not examined. Magnetic resonance imaging has documented that most injuries within the muscles are adjacent to the intramuscular tendon.[8,9]

The finding that abnormalities were present in 61% of the performed scans is in agreement with results of other studies that have used imaging modalities in the diagnosis of acute hamstring injuries. Abnormalities have been found in 75% of elite ARF players with hamstring injuries when using ultrasound[8] and in 55% to 82% when using MRI.[8,14,27,29] Even though all of these studies were conducted in the same sport (ARF), different injury definitions have been used. In the study by Connell et al,[8] players were included if their symptoms were acute onset of posterior thigh pain or stiffness and if they were unable to complete their training session or game. In the studies by Slavotinek et al[27] and Verrall et al,[29] the symptoms did not have to be acute onset, but the injury had to cause the athlete to miss training or playing. Gibbs et al[14] performed a clinical examination and included acute grade 1 (minor) injuries only. It is most likely that the use of different injury definitions influences the results of imaging findings. In the study by Gibbs et al,[14] who included grade 1 injuries only, no more than 55% of the MRI scans showed abnormalities. Contrary to this, Verrall et al[29] showed that 82% of athletes with a hamstring injury had abnormalities on MRI and that 97% of the injuries, which were sudden onset and occurred after a warm-up period, were detectable on MRI.

In the present study, we have used the injury definition recommended by the FIFA Injury Consensus Group.[13] Even though this definition does not restrict injuries to time-loss injuries only, all participants included in the present study had time loss caused by the hamstring injury (6-74 days). Therefore, this definition is identical with the definition used by Connell et al,[8] which makes it appropriate to compare the findings in that study to those of the present study.

In both studies, a considerable proportion (25%-40%) of participants with acute hamstring injuries had no ultrasonographically detectable abnormalities. Whether no abnormalities were present or whether sonography is not sensitive enough to detect these injuries is unknown. It is often postulated that some of the injuries with no detectable abnormalities on imaging are caused by referred pain from the lumbar spine, sacroiliac joints, or hips,[15] even though there is no evidence supporting this theory.

The optimal timing of a sonographic examination after an acute hamstring injury has not been investigated, and this issue may also have influenced the findings. Theoretically, the size of the bleeding and the edema will increase during the first hours/days after the injury and gradually normalize during the subsequent days to weeks. Therefore, if the sonographic examination is performed either too soon or too long after the injury episode, no abnormalities may be present. The time from injury to examination was 0 to 3 days in the study by Connell et al[8] and 1 to 10 days in the present study. However, the wider range from injury to sonographic imaging in the present study reflects the logistical challenges when studying nonprofessional athletes. Contrary to most professional clubs that have (or have access to) a sonographic scanner, this is not the case in nonprofessional setups. In the latter case, the athlete needs a referral for the examination and has to take time off from work to undergo the examination. Therefore, it might be the logistically possible time that decides when the examination is performed, despite the fact that the theoretical examination could have been timed more optimally. However, post hoc analysis showed no signs or trends toward an optimal time period to perform the scan, and the likelihood of a positive ultrasonographic finding was alike when comparing ultrasound examinations performed 1 to 5 days after injury compared with 6 to 10 days ($P = .78$).

Because a considerable number of injuries do not have "macroscopic" evidence on MRI or ultrasound, a recently published consensus statement regarding muscle injuries in sport recommended changing future terminology.[21] Hence, it is recommended to distinguish between structural and functional injuries for injuries with and without MRI or sonographic changes, respectively.

Based on the findings from the present study, it seems that sonographically detectable injuries do not result in a longer return to play compared with nondetectable (by ultrasonography) injuries because the mean absence from soccer in these 2 groups was not statistically significant. Hence, the results of this study question the use of ultrasonography as a supplement to the clinical examination of hamstring injuries. Clearly, ultrasonography is relevant and recommended if a total hamstring muscle rupture or avulsion is suspected because this diagnosis often results in surgical treatment.[5,19] Sonography of partial ruptures, though, seems in this study only to add a limited value of interest for the clinician in the examination of the athlete.

The sizes of the injuries reported in our study appear similar to the injuries documented by Connell et al.[8] They reported a length of injuries from 2 to 50 mm (median, 25 mm) compared with lengths in the present study of 4 to 40 mm (median, 20 mm). However, contrary to Connell et al,[8] we did not find any correlation between the time to return to play and the lengths of the injuries. The reason for this discrepancy is not obvious. It could be hypothesized that injury types and injury mechanisms in soccer and ARF are not identical because of differences between these 2 sports. Also, ARF is played on a field twice as big as a soccer field, which means that players have to cover much longer distances while running at maximal or near maximal speed, which is a known high-risk activity for incurring hamstring injuries. Further, the playing time in ARF is significantly longer with an increasing probability for developing fatigue, which has been proposed as a risk factor for a hamstring injury.[18,31] However, despite the fact that ARF may be an activity with an even higher risk for incurring hamstring injuries compared with soccer, we believe that injury types and injury mechanisms within these 2 sports are similar. This is supported by the fact that the size and localization of the sonographically verified injuries in the present study were similar to those in the study by Connell et al[8] and that it has been documented that most acute hamstring injuries within these 2 sports occur while players are running or sprinting.[1,29,31]

Another explanation of the discrepancy of the correlations between the time to return to play and the sonographically assessed lengths of the injuries in soccer and ARF could be that different "return to play" criteria have been used. Criteria have not been standardized in either of the studies because participants were elite or subelite athletes, making this demand impossible. However, a systematic injury registration system within the ARF league in recent years has found the hamstring injury to be the most common injury type, with a high number of recurrent injuries.[22,26] Because of the substantial focus on this injury type, most medical staff in the ARF league have used a generally accepted rehabilitation program including a progressive hamstring running program as one of the criteria for return to sport.[4] Nevertheless, it seems that injury severity, expressed as the number of days from injury to return to play, is similar in the 2 sports. In the study by Connell et al,[8] the players had a mean time to return to play of 21 days (range, 4-56 days), comparable with the severity seen in our study (mean, 25 days; range, 6-74 days) and in other soccer studies (mean, 18-22 days).[25,31] This may not, however, be the case in other sports. Askling et al[3] have reported a significantly longer time to return to the preinjury level in elite sprinters with first-time hamstring strains (mean, 20 weeks) compared with the number of days stated above in soccer players. This might underline the different demands in different kinds of sport. Clearly, the hamstring muscles have to be "challenged" to produce symptoms because no problems typically are encountered during activities of daily living only a couple of days after the hamstring injury.[30] The most challenging activity for the hamstrings is (high-speed) running, and it has been documented that peak hamstring force occurs during the late swing phase of the running gait cycle and that the force increases significantly with speed.[6] While sprinters obviously focus on high-speed running, soccer players might be less dependent upon this "discipline" because of several other components in play (eg, technical skills, correct positioning, etc), as shown by Mohr et al.[20] Therefore, it is plausible that soccer players may be able to participate in their sport much earlier than sprinters after a hamstring injury but possibly at a reduced level. This issue has been investigated in the ARF league, where player performance, as assessed by the team coach, is reduced in the first 2 games after return to sport after a hamstring injury.[28] This suggests that some players may return to sport before complete healing of the injury. A sprinter either can or cannot sprint, whereas a soccer player may be able to fully participate in all components of play except high-speed running for a longer distance.

A limitation of this study is that the sonographic examinations were performed by 4 different radiologists at 3 different hospitals. This was done because of logistical reasons, as we had to offer the participating players access to a radiologist within an acceptable distance from their home/club because clubs from all Danish regions were included in the study. Because sonography is observer dependent, it would have been valuable to know the interobserver reproducibility of the investigators. Further, a disadvantage of sonography is that this imaging technique includes a long learning curve.[16] However, we have used a standardized protocol when performing the ultrasound examinations, and all 4 radiologists in this study had more than 10 years of experience within the specialty of musculoskeletal sonography. We therefore believe that the findings in the present study are valid in elite and subelite soccer.

CONCLUSION

The biceps femoris is the most commonly injured hamstring muscle detected by ultrasound, and more than half of the injuries are intramuscular. Because neither the presence of sonographic findings nor the size of the findings was correlated with time to return to play in injured soccer players, the prognosis of hamstring injuries should not be guided by these findings alone.

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