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Hamstring Strain Ultrasound Case Series: Dominant Semitendinosus Injuries in National Collegiate Athletic Association Division I Athletes

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Authors of previous studies of patients with acute hamstring strains have reported injury to the biceps femoris and semitendinosus (ST) in 50% to 100% and 0% to 30%, respectively. This retrospective case series of hamstring injuries in National Collegiate Athletic Association Division I collegiate athletes exhibited an injury pattern on ultrasound imaging that differed from what would be expected based on prior literature. We examined ultrasound images of 38 athletes with acute hamstring strains for injury location (proximal muscle, proximal myotendinous junction, midportion of muscle, distal muscle) and affected muscles (biceps femoris, ST, or semimembranosus). Twenty-six athletes (68.4%) injured the ST, and 9 athletes (23.7%) injured the biceps femoris long head. Most athletes (23, 60.5%) injured the proximal portion of the muscle or myotendinous junction. Though this study had many limitations, we demonstrated more frequent involvement of the ST and less frequent involvement of the biceps femoris than reported in the literature.

Key Words: biceps femoris, athletic injuries, lower extremity, thigh

Key Points

- This case series showed much more frequent involvement of the semitendinosus (68.4%) than the biceps femoris long head (23.7%), which was different from prior literature.
- Given these findings, as well as recent improvements in magnetic resonance imaging and ultrasonography, re-examining the frequency of hamstring muscle injuries and comparing the ultrasound findings with magnetic resonance imaging results may be warranted.

Acute hamstring strains are common injuries in many sports.[1] Hamstring strains may cause significant pain, disability, and time away from sport. They have been reported to make up 12% of injuries per season in British soccer and 15% of injuries per season in Australian rules football.[1] Additionally, recurrence rates of 12% and 34% were observed in these respective sports.[2,3]

Acute hamstring strains most commonly occur during rapid eccentric activation of the hamstring, primarily during the terminal swing phase of high-speed running.[1,4] The long head of the biceps femoris at the proximal myotendinous junction (MTJ) was the most frequent injury site.[5] Previous authors who studied hamstring injuries reported injury to the biceps femoris in 50% to 100%, with most studies demonstrating injury to the biceps femoris in 70% to 80% of cases,[6–12] sole or primary injury to the semimembranosus in 0% to 23.5%, and sole or primary injury to the semitendinosus in 0% to 30%.[6–12] Although isolated injury occurs most often, simultaneous injury to multiple muscles within the hamstring muscle complex is also possible.[5,7,9–11]

Evaluation of a patient with a hamstring injury involves a careful history, physical examination, and consideration of advanced imaging, which assists us in determining the injury location and severity and prognosticating return-to-play timelines. Magnetic resonance imaging (MRI) is considered the criterion standard imaging modality because of its ability to reveal hamstring injuries at the muscle, tendon, and MTJ. Magnetic resonance imaging can also characterize injury during the acute, subacute, and chronic phases of injury. In comparison, conventional radiographs are more useful to evaluate osseous avulsion injuries.[13] Imaging can also be beneficial for prognostication, as athletes with larger lesions had a higher risk of recurrent hamstring injury,[10,14] and MRI grading of hamstring injuries correlated with return-to-play time.[12,15] In recent years, ultrasound has become a more accessible and less costly imaging modality for evaluation of musculoskeletal injuries. Ultrasound has many advantages, including availability, relatively low cost, and dynamic assessment, such as sonopalpation. Additionally, ultrasound is now being incorporated into medical student and resident education; increasingly affordable ultrasound units allow improved access. Despite the differences between MRI and ultrasound, ultrasound had equal sensitivity in the acute setting for assessing hamstring injuries in 1 study.[11]

To date, authors have described the semitendinosus (ST) as a less often injured hamstring muscle.[6–11] In this case series, however, we demonstrated a markedly higher frequency of

Table. Hamstring Injuries by Muscle and Injury Location

Muscle Injured	Total No.	Injury Location: Proximal	Proximal Myotendinous Junction	Midportion of Muscle	Distal Muscle
Biceps femoris					
Long head	9	1	0	6	2
Short head	0	0	0	0	0
Semitendinosus	26	7	12	7	0
Semimembranosus	2	2	0	0	0
Biceps femoris long head and semitendinosus (proximal portions)	1	1	0	0	0
Total	38	11	12	13	2

ST injuries among athletes than would be expected based on the literature.

Patients

These cases are a series of 38 elite athletes from a single National Collegiate Athletic Association (NCAA) Division I intercollegiate athletics program between 2018 and 2020. We identified 61 ultrasound evaluations of the posterior thigh. Thirteen were follow-up scans of the same athletes and were excluded. Additionally, we excluded 10 either because the ultrasound scans were not characterized as representing a hamstring strain or the ultrasound evaluation was not considered diagnostic.

Interventions and Assessments

All ultrasound examinations were performed using an ultrasound device (model HM70A; Samsung) with a 3- to 16-Hz linear array transducer or a 2- to 7-Hz curvilinear transducer. Each athlete presented for evaluation in the sports medicine clinic within 1 week of the initial injury and was evaluated by the head team physician, who was fellowship trained in sports medicine and musculoskeletal ultrasound. The location and severity of each injury were identified using ultrasound, in conjunction with the athlete's history and physical examination. The ultrasound images were further classified by injury location (proximal, proximal MTJ, mid, or distal hamstring) and the muscle involved (biceps femoris short head, biceps femoris long head [BFLH], ST, or semimembranosus).

Comparative Outcomes

Of the 38 athletes examined, 26 (68.4%) injured the ST, and 9 (23.7%) injured the BFLH. Most hamstring strains (both ST and overall) involved the proximal MTJ, followed by the proximal muscle. The Table provides the injury location totals for the cases, and the Figure supplies the ultrasound images and transducer position for 1 athlete with an injury of the proximal ST.

DISCUSSION

In this case series, we demonstrated more common involvement of the ST muscle in hamstring strains than previously documented in the literature. Here, 68.4% of cases involved the ST, whereas the frequency of ST involvement as the sole or primary muscle injured has been reported as 0% to 30% of hamstring injuries.[6–12] The BFLH, however, was injured in 23.7% of the cases in this series, less than the earlier cited frequency of 50% to 100% of hamstring injuries.[6–11]

The higher frequency of injury to the ST in hamstring strains could be explained by preferential increased loading during certain activities. De Smet et al[9] noted that all athletes with isolated ST injury were track and field jumpers. The authors hypothesized that the combination of hip flexion and knee extension in track and field jumpers may place the ST at greater risk.[9] Preferential activation in certain exercises[16] and in sprinting has been observed.[17] Higashihara et al[17] identified greater ST than BFLH activation during the terminal midswing phase of a maximal sprint, which is when most hamstring injuries occur.

Several limitations to this case series exist. The first limitation was the small sample size of NCAA Division I intercollegiate athletes. The results are specific to this group and may

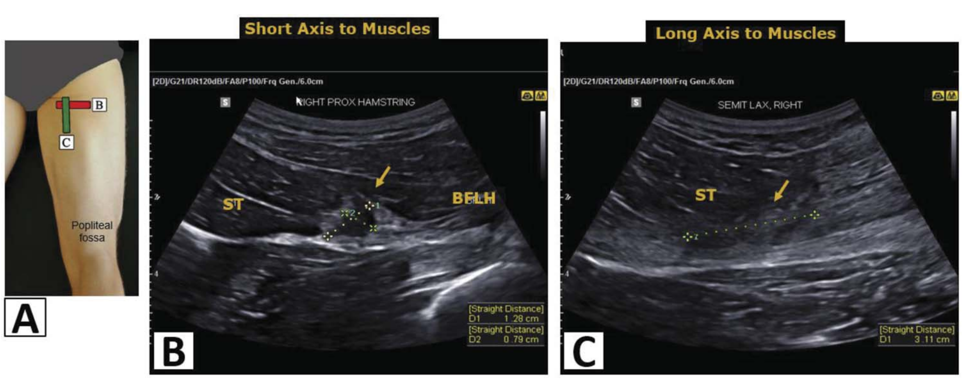

Figure. Proximal semitendinosus (ST) injury—athlete Z. A, Transducer position for B and C. B, Short axis sonographic image of the proximal hamstrings demonstrating a 1.28- × 0.79-cm tissue defect. C, Long axis ultrasound image demonstrating a 3.11-cm tissue defect. Abbreviation: BFLH, biceps femoris long head.

not be generalizable to other populations of athletes. However, in much of the prior literature on hamstring strains, authors have also studied high-level athletes, including collegiate and professional athletes.[2,3,5,9,10,12,14,15,18,19] As this is an observational study with no comparison group, the incidence and prevalence of hamstring injuries among NCAA Division I intercollegiate athletes cannot be determined from this sample. Additionally, the athletes' histories, including the mechanism of injury, sport, position, exact time from injury to initial ultrasound evaluation, and any prior hamstring injuries, were not available for review. The lack of history, physical examination findings, and comparison with MRI findings limits the outcomes of our study, as the ultrasound results stand alone with less clinical context for interpretation or advanced imaging comparison. Overall, these restrictions curtail our ability to fully understand the clinical history or clinical outcomes, as our analysis was focused on 1 snapshot in time seen on ultrasound. Further imaging and clinical correlation would be beneficial to add broader context to interpreting these results for athletes as well as our understanding of how ultrasound may play a role in the clinical standard of care.

Despite the many limitations to the interpretation of our case series, the use of point-of-care ultrasound for athletes did provide a relatively timely, quick, and inexpensive imaging modality to assist in understanding the degree and location of hamstring injury. We acknowledge the inherent bias of 1 ultrasonographer interpreting all results, yet we provide evidence to support greater involvement of the ST than the BFLH, compared with previous studies. Although ultrasound as a diagnostic tool is a user-dependent modality, Kellis et al[20] reported interrater intraclass correlation coefficients between 0.83 and 0.99 (ie, good reliability), with variability of less than 4.69% in experienced sonographers after an evaluation protocol of distal BFLH strains. Several authors have described ultrasound as a valid and reliable tool for measuring the architectural features of the hamstring.[21–23] Furthermore, in our case series, inconsistent documentation (the number of saved images, labeling, and quality of visualization) limited comparability among cases. However, we attempted to minimize this concern by excluding 5 scans that were nondiagnostic.

Connell et al[11] showed that MRI and ultrasound evaluation were equally sensitive for the initial diagnostic evaluation of hamstring injuries. Nonetheless, the injury extent was consistently larger on MRI due to the increased ability to detect edema, and differences between MRI and ultrasound were found when the injury was small.[11] They also indicated that, in several cases, abnormalities that appeared to affect the ST on sonography appeared as BFLH irregularities on MRI.[11] They suspected that this was likely related to the difficulties in differentiating the BFLH and ST on sonography because of their common origin.[11] In our case series, the interpretation of our findings was restricted by the lack of MRI comparisons.

Most published examinations of hamstring strain muscle and location predate 2008,[6–12] with some studies published before 2000.[7,8] In more recent literature, as well as anecdotal experience, authors have described the improved MRI resolution[24] as well as new ultrasound techniques for evaluating tendon injury (ie, shear wave elastography).[25] Although these alternative techniques were not used in our case series, such techniques in the future may improve the evaluation of hamstring injuries, including characterizing the severity and location.

Certain exercises can cause preferential activation of different hamstring muscles,[16,17,26] yet current protocols for rehabilitation and return to play after hamstring injury do not delineate the treatment or exercise choice based on which hamstring muscle is injured.[26,27] However, this may be because most earlier authors[6–11] reported the BFLH as the primary injured muscle in the large majority of cases, and limited data exist on specific rehabilitation protocols based on each specific injured muscle. In the future, the ability to use ultrasound to identify the specific injured muscle may lead the athlete's physician, athletic trainer, or physical therapist to modify the rehabilitation protocol accordingly.

Clinical Bottom Line

Although prior authors described the highest incidence of hamstring strains in the BFLH, in this ultrasound case series of NCAA Division I athletes, we demonstrated most hamstring strains affected the proximal ST. Earlier authors, primarily using MRI, identified the BFLH as the most commonly injured hamstring muscle, but, given the findings of this case series as well as recent improvements in MRI and ultrasonography, re-examining the frequency of hamstring muscle injuries and comparing ultrasound findings with MRI may be warranted.

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