Journal of Science and Medicine in Sport 19 (2016) 317–322

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Acute hamstring injury in football players: Association between anatomical location and extent of injury—A large single-center MRI report

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ARTICLE INFO

Article history:
Received 29 September 2014
Received in revised form 4 February 2015
Accepted 8 April 2015
Available online 15 April 2015

Keywords:
Hamstring
Muscle skeletal
Magnetic resonance imaging
Soccer
Football
Leg injuries

ABSTRACT

Objectives: To describe in detail the anatomic distribution of acute hamstring injuries in football players, and to assess the relationship between location and extent of edema and tears, all based on findings from MRI.
Design: Retrospective observational study.
Methods: We included 275 consecutive male football players who had sustained acute hamstring injuries and had positive findings on MRI. For each subject, lesions were recorded at specific locations of the hamstring muscles, which were divided into proximal or distal: free tendon, myotendinous junction, muscle belly, and myofascial junction locations. For each lesion, we assessed the largest cross-sectional area of edema and/or tears. We calculated the prevalence of injuries by location. The relationships between locations and extent of edema and tears were assessed using a one-sample *t*-test, with significance set at $p < 0.05$.
Results: The long head of biceps femoris (LHBF) was most commonly affected (56.5%). Overall, injuries were most common in the myotendinous junction and in proximal locations. The proximal myotendinous junction was associated with a greater extent of edema in the LHBF and semitendinosus (ST) muscles ($p < 0.05$). Proximal locations in the LHBF had larger edema than distal locations ($p < 0.05$). Distal locations in the ST muscle had larger tears than proximal locations ($p < 0.05$).
Conclusions: The proximal myotendinous junction (LHBF and ST muscles) and proximal locations (LHBF muscle) are more commonly affected and are associated with a greater extent of edema in acute hamstring muscle injury. Distal locations (ST muscle), however, seem to be more commonly associated with larger tears.

1. Introduction

Muscle injuries of the lower limbs are common in football (soccer) players,[1–3] and over 90% of these affect four major muscle groups, the hamstrings, the posterior calf, the adductors, and the quadriceps group.[4,5] The hamstring muscle complex is most commonly affected by injuries in professional football with a reported prevalence of 37% of all muscle injuries in a large prospective cohort, and accounting for 12% of all injuries.[1,6] Within the hamstring group, the biceps femoris is the muscle most frequently affected.[1,6]

Magnetic resonance imaging (MRI) is considered the reference standard to confirm and evaluate the extent and severity of muscle injuries, including the hamstring complex.[7,8] Previous studies demonstrated that some features of hamstring injuries depicted on MRI such as location,[2,9,10] including the central tendon of biceps femoris involvement, proximal injury (mainly proximal myotendinous junction), and proximal free tendon involvement, as well

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http://dx.doi.org/10.1016/j.jsams.2015.04.005
1440-2440/

as extent of injury, [7,11,12] i.e., longitudinal length or the cross-sectional (percentage of) area of injuries, correlate with longer recovery times or risk of recurrent injury.[11,13,14] Most of these studies assessed the extent of injury by measuring a composite of total volume or area taking into account regions of edema with or without tears combined, without differentiating the different manifestations of injury.[15–17]

It might be clinically relevant to know which locations are associated with more severe injury (i.e., macroscopic tears and not only edema; extent of injury), as this can affect treatment decisions and prognosis. Prompt clinical examination at the time of injury may provide important information about the location of the injury,[15] and knowing how the location of the injury relates to the extent of the injury could give initial prognostic information.

The aims of this study were (1) to describe the different anatomical locations of acute injuries within the hamstring complex and within each muscle, in a large retrospective cohort of football players; (2) to measure the extent (cross-sectional area) of edema and/or tear; and (3) to assess the relationship between specific locations or groups of locations and the extent of edema and/or tear.

2. Methods

A retrospective review was performed of all consecutive MRIs of male football players referred to the department of radiology of (blinded) with a clinical diagnosis of acute hamstring injury. For the purpose of this study, only MRI assessments performed within five days following the hamstring injury were considered in our retrospective review. The records we reviewed dated from 2009 to 2012. The players were registered football players from (blinded). This study was approved by the local institutional review board (IRB) which also waived the requirement for signed informed consent due to the retrospective nature of this study (blinded). Only players with an acute hamstring injury and with positive findings on MRI were included in this analysis.

All examinations were performed on a 1.5 T MRI (Magnetom Espree, Siemens, Erlangen, Germany) using a phased-array surface coil strapped over the thigh and centred over the region of maximal tenderness as identified by the player (skin markers were positioned accordingly). The MRI protocol included coronal proton density-weighted (PDw) fat-suppressed (FS) fast spin-echo (FSE) (repetition time (TR) 3900 ms; echo time (TE) 25 ms; field-of-view (FOV) $23 \times 33\,cm^2$; slice thickness 4 mm; interslice gap 1 mm), sagittal PDw FS FSE (TR 3670 ms; TE 25 ms; FOV $26 \times 33\,cm^2$; slice thickness 4 mm; interslice gap 1 mm), axial T2-weighted FS FSE (TR 5720 ms; TE 74 ms; FOV $28 \times 28\,cm^2$; slice thickness 5 mm; interslice gap 1.2 mm), and axial T1-weighted FSE (TR 705 ms; TE 11 ms; FOV $28 \times 28\,cm^2$; slice thickness 5 mm; interslice gap 1.2 mm).

A single radiologist (blinded) with seven years of experience in musculoskeletal radiology and six years of experience in semiquantitative and quantitative MRI assessment first reviewed all MRIs of players with suspected hamstring muscle injuries in order to define positive and negative (no pathology detected) findings. The positive MRIs were evaluated in detail two months after the initial assessment. The MRI reader was blinded to clinical data as well as to other imaging data.

Lesions were initially assessed individually using all MRI sequences acquired in the three planes, in order to evaluate the whole extension and spectrum of injuries depicted. When two (or more) separate non-contiguous lesions were observed in a single muscle, the lesions were regarded as two distinct lesions (i.e., two lesions were recorded). If lesions were found in more than one muscle, again each lesion was recorded separately. Thus, in this study, some subjects could present with more than one acute lesion.

For each hamstring muscle, locations were recorded as follows: (1) proximal tendon, (2) proximal myotendinous junction, (3) proximal muscle belly, (4) distal muscle belly, (5) distal myotendinous junction, (6) proximal myofascial junction, and (7) distal myofascial junction (Fig. 1a). Distal tendons were not taken into account since the majority of the MRIs did not cover the distal insertions of the muscles.

Lesions were defined by any one or more of these findings:

- An area of edema (Fig. 1b), visualized as poorly-defined high-signal intensity on PDw FS sequences.
- Areas of tears (Fig. 1c), with partial or complete discontinuity/disruption of the muscle fibers, seen as well-defined fluid-equivalent high-signal intensity on PDw FS sequences.
- Signal abnormalities around the myotendinous junction (Fig. 1d) and/or the myofascial junction (Fig. 1e), with or without discontinuity of the central tendon and/or the fascia.
- Involvement of the proximal and/or distal tendons, with or without associated fluid collection or hematoma surrounding the aponeurosis of the muscle affected.

For each muscle, lesions were coded as 1 (first lesion), 2 (second lesion), and so on for each additional lesion.

Because the extent of edema is related to clinical outcome and risk of re-injury,[2,7–9,11–15,17] we assessed the presence and the extent of edema on MRI for each lesion. In the axial plane, the slice showing the largest area of edema was used as the reference for measuring the cross-sectional area of edema (in cm^2) in that lesion. This was achieved by manual segmentation of the edema within that slice. As the presence of a macroscopic tear (fiber disruption) is relevant for prognosis,[2,11] since it is associated with longer recovery times when compared to injuries having only edema, we also assessed the presence and the extent of the tear for each lesion. The axial slice showing the largest area of the tear was used as the reference for measuring the cross-sectional area (in cm^2), by manual segmentation. Finally, the specific location of the tear was noted separately.

Descriptive analysis was performed to show the prevalence of acute hamstring lesions, using these parameters:

- The specific muscle location for each muscle: long head of biceps femoris—LHBF; short head of biceps femoris—SHBF; semitendinosus—ST; and semimembranosus—SM.
- The specific locations (described above) and some groups of locations: myotendinous junction; muscle belly; myofascial junction; proximal locations combined; and distal locations combined.

The presence of edema and/or tears in each lesion, as well as the mean value (standard deviation) of the cross-sectional area of edema and area of any tear for each location (and groups of locations described above) in each muscle was assessed.

We considered the LHBF and SHBF as distinct structures since the SHBF does not cross the same number of joints as other hamstring muscles do. We also assessed the average (mean value) of the areas of edema and tear for each muscle in the whole sample. Muscles were evaluated separately due to their distinct anatomy. Further, the relationship between specific locations (including some groups of locations) and the cross-sectional area of edema and tears was assessed using one-sample *t*-test, using the average (mean value) of these features in each muscle in the whole sample as the reference standard for analysis. Finally, we performed linear regression analysis to directly compare the average values of edema and tears between proximal and distal locations overall. Since a single lesion could be present in more than one of the defined locations (as well as the edema or tearing measured for that specific lesion), especially in cases of extensive injury, we considered each location