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SCIENTIFIC LETTER

# Length of the free tendon is not associated with return to play time in biceps femoris muscle injuries

## La longitud del tendón libre no está asociada al tiempo de vuelta a la competición en las lesiones musculares del bíceps femoral

Injuries of the hamstring muscle complex are very common injuries in sports, representing 12% of all injuries and 37% of all muscle injuries in professional football[1] with biceps femoris as the most frequently (84%) injured hamstring muscle.[2]

The long head of the biceps femoris originates on the posterior aspect of the ischial tuberosity. It shares a footprint and (portion of its) tendon with the semitendinosus.[3–8] The tendon can subdivided into a 'free' and 'intramuscular' tendon (sometimes referred to as 'central tendon'[9–11]). The free tendon is defined as the part of the tendon that has no muscle fibers inserting onto it, the remaining part of the tendon is referred to as the intramuscular tendon.

In multi-sports club Futbol Club Barcelona (FC Barcelona), anecdotal clinical observations led to the clinical suspicion that a short proximal free tendon in injuries of the long head of the biceps femoris (BFLH) was associated with a quicker return to play (RTP). Measurement reliability and potential prognostic value (i.e. time to return to play) of free proximal tendon length have not yet been evaluated. Our hypothesis is that a shorter proximal BFLH free tendon is associated with a shorter time to return to play (RTP).

Therefore, the primary aim of the present study was:

- To evaluate the reliability of the proximal BFLH free tendon measurement on magnetic resonance imaging (MRI).
- To evaluate the association between proximal BFLH free tendon length and time to RTP in days.

## Methods

### Subjects

To address our research question, a study population comprised of two different study cohorts was used (50 Catalan cohort and 58 Qatari cohort). Patients with acute hamstring injuries were either recruited at the multi-sports club FC Barcelona, or were part of a double-blind randomized controlled trial (RCT) investigating the effect of platelet-rich plasma (PRP) in acute hamstring injury on time to RTP.[13] This RCT did not show a benefit of PRP over placebo. Eligibility criteria for both study cohorts are shown in Box 1.

Ethical approval was obtained from the Ethical Committee of ASPETAR (Orthopaedic and Sports Medicine Hospital) and the Consell Català de l'Esport (Generalitat de Catalunya). Informed consent was obtained from all included subjects.

### MRI protocol

At FC Barcelona, images were acquired with a 3.0 T magnet system (Siemens, Erlagen, Germany). Subjects were positioned inside the scanner with both legs parallel to the MRI table, and the thighs were covered with multichannel coils. Coronal and axial T1-weighted images (TR/TE 900/15 ms; FOV 330 mm $\times$ 300 mm; slice thickness 3.5 mm; matrix 384 $\times$ 512) were obtained. Coronal and axial T2 fat sat (TR/TE 4000/35 ms; FOV 330 mm $\times$ 300 mm; slice thickness 3.5 mm; matrix 320 $\times$ 384) as well as sagittal T2 (TR/TE 4000/32 ms; FOV 330 mm $\times$ 300 mm; slice thickness 2.0 mm; matrix 320 $\times$ 384) was obtained.

In the ASPETAR cohort, images were acquired with a 1.5T magnet system (Magnetom Espree, Siemens) and a body matrix coil. Coronal and axial proton density (PD) weighted images (TR/TE 3000/32 ms; FOV 240 mm; slice thickness 5 mm; matrix, 333 $\times$ 512) were obtained. Subsequently, coronal and axial proton density weighted images with fat

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**Box 1**

| Study cohort | Catalan cohort | Qatari cohort (Hamilton et al.[12]) |
|---|---|---|
| Inclusion criteria | • Acute onset of posterior thigh pain<br>• Localized pain on palpation<br>• Localized pain of passive stretching<br>• Increased pain on isometric contraction<br>• MRI confirmed a grade I or II BFLH lesion | • Age 18–50 years<br>• Available for follow-up<br>• Acute onset of posterior thigh pain<br>• Presenting an MRI within 5 days from injury<br>• MRI confirmed a grade I or II BFLH lesion<br>• Male gender<br>• Able to perform five sessions of physiotherapy a week at our clinic |
| Exclusion criteria | • Contraindication to MRI<br>• Chronic hamstring injury<br>• Concurrent other injury inhibiting rehabilitation | • Contraindication to MRI<br>• Reinjury or chronic hamstring injury<br>• Concurrent other injury inhibiting rehabilitation<br>• Unwilling to comply with follow-up<br>• Needle phobia<br>• Overlying skin infection<br>• Diabetes, immunocompromised state<br>• Medication with increasing bleeding risk<br>• Medical contraindication to injection |

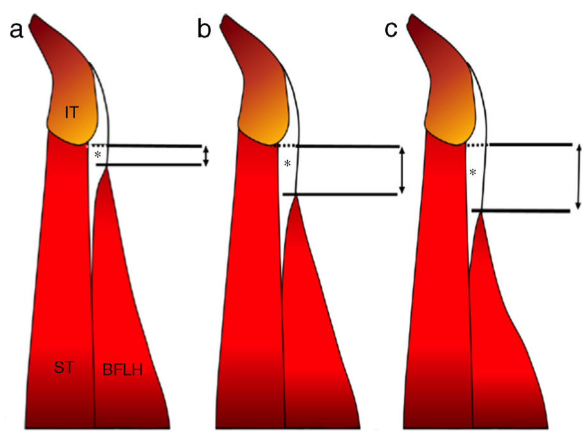


**Figure 1** Proximal BFLH free tendon length is measured (in cm) from the most inferior margin of the ischial tuberosity to the point where the first muscle fibers start to insert onto the tendon. IT: ischial tuberosity; ST: semitendinosus; BFLH: long head of the biceps femoris; *: free tendon. (a) Short free tendon, (b) medium free tendon and (c) long free tendon.

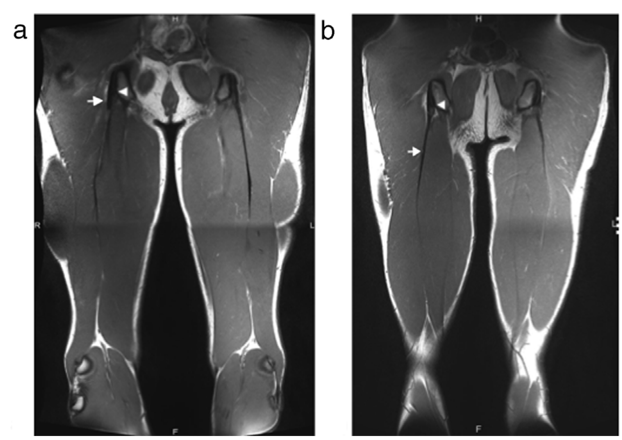


**Figure 2** T1 coronal MRI of a short free tendon (a) and long free tendon (b) are shown. Arrowheads show the most inferior margin of the ischial tuberosity and arrows show the point where the first muscle fibers started to insert onto the tendon.

saturation (PD-FS) were obtained (TR/TE 3000/32 ms; FOV 240 mm; slice thickness 3.5 mm; matrix 326 × 512 for coronal and TR/TE 3490/27 ms; FOV 320 mm; slice thickness 3.5 mm; matrix 333 × 512 for axial).

## MRI assessments

Each MRI was assessed by one of the two musculoskeletal radiologists, who were blinded to clinical outcome. Each radiologist scored the MRIs in a random order between July 2009 and July 2016. The free proximal BFLH tendon measurement is shown in Figs. 1 and 2.

## Rehabilitation protocol

The rehabilitation protocols used in both cohorts are described in detail in previous studies.[13,14]

## Outcome measures

At FC Barcelona, the RTP decision is made based on clinical assessment, sport-specific field tests and imaging.[15,16] The field test includes a comparison of data such as workload parameters (including GPS) with athlete-specific pre-injury data. No specific pre-defined criteria were used. Time to RTP was defined as the number of days from initial injury

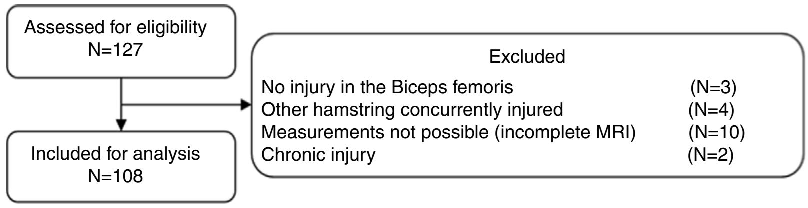


**Figure 3** Flow diagram of the inclusion process.

until the athlete was cleared by one of the team physicians to resume full, unrestricted training.

In the ASPETAR cohort, the guidelines for making the final RTP decision included successful and asymptomatic completion of the progressive criteria-based rehabilitation program including three sport-specific phases, clinical evaluation by an experienced sports medicine physician, and interpretation of the results of an isokinetic assessment. The physician's final decision was guided, but not determined by these medical factors, and also included consideration of sport risk modifiers and decision modifiers.[17,18]

### Statistical analysis

Statistical analysis was carried out using IBM SPSS Statistics (version 21, IBM Corp.). Continuous variables were tested for normality and presented as mean (±SD) unless otherwise stated. To evaluate intra-observer reliability, one of two specialized musculoskeletal radiologists recorded free tendon length bilaterally in 30 subjects. The same radiologist repeated the measurements one week later. To evaluate inter-observer reliability, both radiologists performed the measurements independently. Intraclass correlation coefficient (ICC) analysis was carried out to determine intra- and inter-observer reliability. We used Cronbach's $\alpha$ and the model for the computation of ICC was a two-way mixed (people effects are random, and the item effects are fixed). Reliability was considered excellent if the ICC is >0.75, fair to good if $0.4 < ICC < 0.75$ and poor if ICC is <0.4. The Pearson correlation coefficient was used to analyze the relationship between tendon length (in cm) and time to RTP (in days). Statistical significance was set at $p < 0.05$.

**Table 1** Baseline characteristics of the included subjects.

| | *N* = 108 |
|---|---|
| *Age (years)* | 25 (±5.8) |
| *Sports category* | |
| Athletics | 4 (4%) |
| Baseball | 1 (1%) |
| Basketball | 7 (7%) |
| Decathlon | 1 (1%) |
| Field hockey | 7 (7%) |
| Football | 63 (58%) |
| Futsal | 7 (7%) |
| Handball | 2 (2%) |
| Physical coach | 1 (1%) |
| Track and field | 13 (12%) |
| Volleyball | 1 (1%) |
| Weight lifting/body building | 1 (1%) |
| *Side injured* | |
| Right | 68 (63%) |
| Left | 40 (37%) |
| Bilateral | 0 (0.0%) |
| *Injury location* | |
| Proximal | 78 (72%) |
| Distal | 30 (28%) |
| *Anatomic location* | |
| Free tendon | 0 (0%) |
| Musculotendinous junction | 104 (96%) |
| Myofascial | 4 (4%) |
| *Free tendon length (BFLH)* | |
| Right free tendon length (cm) | 4.8 (±2.4) |
| Left free tendon length (cm) | 5.0 (±2.2) |

## Results

From 2008 to 2014, 108 athletes with a BFLH injury were included for analysis (Fig. 3).

Demographics and injury characteristics at baseline are shown in Table 1.

### Reliability

ICCs for intra-observer and inter-observer reliability of the free tendon length measurement (cm) are presented in Table 2.

### Free tendon length and RTP time

Average length of the free proximal BFLH tendon was $4.8 \pm 2.4$ cm on the right side, and $5.0 \pm 2.2$ cm on the left side. Average time to RTP was $29 \pm 15$ days. There was no statistically significant correlation between free proximal BFLH tendon length in cm and time to RTP in days (Pearson correlation coefficient = −0.037; $p = 0.712$). Fig. 4 shows a scatter plot for these parameters.

## Discussion

In the present study, we sought to determine whether or not a relationship exists between proximal BFLH free tendon length and RTP time, a hypothesis that was formed based on clinical observations. The presented measurement of proximal BFLH free tendon length has excellent intra- and

**Table 2** Intraclass correlation coefficients (ICC).

| Reliability | Tendon | ICC | 95% CI | *p*-Value | Strength of agreement |
|---|---|---|---|---|---|
| Intra-observer | Right | 0.983 | 0.963–0.992 | <.001 | Excellent |
| | Left | 0.921 | 0.832–0.963 | <.001 | Excellent |
| Inter-observer | Right | 0.984 | 0.966–0.993 | <.001 | Excellent |
| | Left | 0.977 | 0.952–0.989 | <.001 | Excellent |

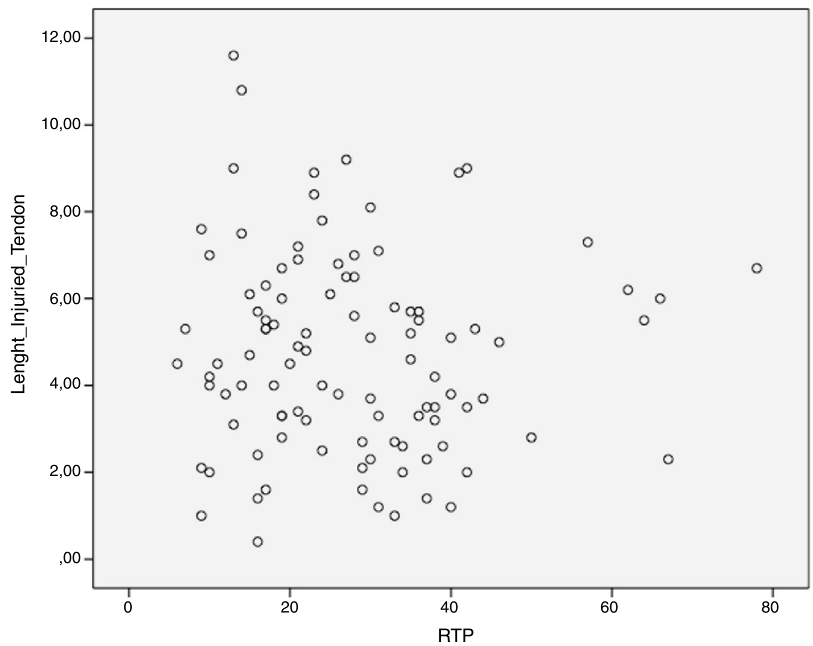


**Figure 4** Scatter plot for RTP (days) and free proximal BFLH tendon length (cm).

inter-observer reliability. However, there was no correlation between tendon length (cm) and RTP time (days).

## Long head biceps femoris proximal free tendon and RTP

Athletes in the current study are predominantly football players and track and field athletes with a mean time to RTP of approximately 4 weeks. For comparison: a large study on RTP in (elite) football reported that 84% of injuries involved the biceps femoris, with a mean time to RTP of $20 \pm 15$ days.[19] Askling et al.[20] studied 18 sprinters who all had the primary injury in the biceps femoris with a median time to return to pre-injury activity level of around 16 weeks (range 6–50 weeks).

According to our measurements, average proximal length of BFLH free tendon was $4.8 \pm 2.4$ cm on the right side and $5.0 \pm 2.2$ cm on the left side. A recent anatomical study of the hamstring muscle complex included muscle and tendon lengths and reported an average proximal BFLH free tendon length of $5.0 \pm 3.4$ cm.[5] Although this study involved measurements upon dissection, the average of this tendon length corresponds well with our measurements on MRI.

The clinical suspicion that proximal BFLH free tendon length might impact recovery was partly due to observations in clinical practice, and partly due to recent attention for the effect of musculotendinous architecture on injury risk.[21–23] Hypothetically, if certain architectural characteristics result in conditions that may predispose to muscle injury, they could also potentially result in less favorable conditions for muscle recovery. We sought to investigate whether this was the case for proximal free tendon length. Nonetheless, our data do not indicate that free proximal BFLH tendon length influences time to RTP following acute hamstring injury in athletes.

In any case, is interesting to note that tendinous injuries (for example proximal BFLH free tendon tears) could need a surgical intervention for a whole healing because in case of perform a conservative treatment the RTP is much longer and the risk of reinjury are high.[24] However, a recent work[25] has pointed that RTP in intramuscular hamstring tendon injuries is only significantly longer compared with injuries without intramuscular tendon disruption.

### Limitations

The subjects in this study were either participants in a randomized controlled trial (Qatari cohort) or athletes of FC Barcelona (Catalan cohort) with some differences in eligibility criteria, MRI protocols and RTP criteria. Although this may reflect clinical practice, it can be considered as a limitation. In addition, a univariate analysis was used. Therefore, we have not controlled for potential confounders.

### Future research

Aside from impact on recovery, in accordance with recent studies on architectural characteristics it would be interesting to investigate whether free proximal BFLH tendon length is a risk factor for injury and re-injury. This requires prospective study designs.

## Conclusion

Free tendon length can be reliably measured with excellent intra-observer and inter-observer agreement. In long head biceps femoris injury, length of the proximal free tendon is not associated with time to return to play.

## Conflict of interests

The authors declare that that they have no competing interests.

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