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Hamstring muscle strain in sprinters

By Carl Askling and Alf Thorstensson

ABSTRACT

Hamstring muscle strains are common in athletics, especially in the sprints and jumping events, and often cause extended absences from training and competition. At present, there are no studies systematically following acute hamstring strains over time with repetitive clinical examinations and correlating the findings with the actual time to return to sport. Magnetic Resonance Imaging (MRI) offers a means of non-invasively determining the location and extent of a hamstring strain. Since MRI investigations are both expensive and demand expert evaluation, simpler clinical assessment methods would be preferable. Such methods have, however, to be validated with parallel MRI-investigations. The aim of this study was to systematically follow the first six weeks after acute first-time hamstring strains in sprinters, with respect to injury situation, injury location and extent of the injury, recovery of strength, flexibility and function, as well as possible relationships between clinical and MRI findings and time to return to sport during a follow-up period of two years. This project was named the overall winner in the 2008 European Athletics Innovation Awards.

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Introduction

Hamstring muscle strains are common in athletics and often cause extended absences from training and competition. Although systematic epidemiological studies are scarce, testimonies from coaches and athletes point to a high frequency of hamstring injuries, especially in sprinting and jumping events. As an example, four of the five top Swedish hopes for Olympic medals in 2008 in the hurdles and jumping events suffered hamstring strains during the year leading up to the Games.

The collective term "hamstrings" refers to four muscles located in the posterior compartment of the thigh: semitendinosus (ST) and semimembranosus (SM) medially, and biceps femoris, long head (BFlh) and short head (BFsh) laterally. Proximally, BFlh and ST arise from a common overall origin on the ischial tuberosity, but independent origins can be identified for these two muscles on the lateral one-quarter of the medial portion of the ischial tuberosity.[21] The proximal tendon of SM passes lateral and deep in relation to those of BFlh and ST, to insert on the lateral part of the upper half of the ischial tuberosity.[21] Furthermore, the four hamstring muscles differ from each other with respect to muscle architecture, e.g. fascicular length, physiological cross-sectional area, length of the proximal and distal free tendons and extent of the intramuscular tendons.[8,21]

The diagnosis of a hamstring strain is commonly based on a clinical examination, which usually includes questions about the injury situation combined with palpation to detect local pain and loss of function.[17] It is often difficult to acutely examine a hamstring strain because of pain and tenderness, so the general recommendation is to follow up the acute inspection with a new clinical examination the day after the injury occurrs. Suspected total ruptures should immediately be referred to hospital care. At present, there are no studies systematically following acute hamstring strains in sprinters over time with repetitive clinical examinations, including documentation of injury situation, observation of function, location of pain by palpation, measurements of strength and flexibility, and correlating the findings with the actual time to return to sport. Magnetic Resonance Imaging (MRI) offers a means of non-invasively determining the location and extent of a hamstring strain because of its multi-planar capability and high sensitivity to detect the edema that results from soft-tissue injury. Since MRI investigations are both expensive and demand expert evaluation, simpler clinical assessment methods would be preferable. Such methods have, however, to be validated with parallel MRI-investigations.

Making accurate predictions of recovery time is essential for hamstring strains, where prolonged rehabilitation times and re-injuries are common.[6,11,12,15] There are indications that the injury location and size are factors to consider when making estimates of time back to sport. In addition, it could be that injury site in terms of specific muscle in the hamstring muscle synergy and region in the muscle-tendon complex could be of importance. Clinical tests and MRI investigations may be helpful in predicting rehabilitation time as may measurements of strength and flexibility. However, the usefulness of these tests as predictors for time to return to sports after hamstring strains, in general, and those encountered by sprinters, in particular, remains to be demonstrated. Currently, there is no consensus guidelines or criteria for safe return to competition following hamstring muscle strains that maximize performance and minimise the risk for injury recurrence.

The aim of the present project was, therefore, to systematically follow the first six weeks after acute first-time hamstring strains in sprinters, with respect to injury situation, injury location and extent of the injury, recovery of strength, flexibility and function, as well as possible relationships between clinical and MRI findings and time to return to sport during a follow-up period of two years. The main part of the project was published in the American Journal of Sports Medicine in 2007.[2]

Table 1: Characteristics, median values and ranges, of the sprinters included in the study.

	Sprinters	
	Women (8)	Men (10)
Age (years)	22 (20-28)	19 (15-23)
Body height (m)	1.76 (1.59-1.80)	1.78 (1.66-1.82)
Body mass (kg)	65 (53-69)	70 (61-84)
Personal best 100m (s)	12.7 (12.4-13.4)	11.2 (10.5-11.7)

Methods

Subjects

The sprinters were recruited in response to information given to all major track and field clubs in Sweden via the Swedish Athletic Association.

Inclusion/exclusion criteria

To be included the sprinters had to present a history of first-time acute sudden pain from the posterior thigh when training or competing. The clinical examination two days post-injury had to reveal distinct pain when palpating the hamstring muscle, local pain when performing a passive straight leg raise (SLR) test and an increased pain when adding a voluntary isometric hamstring contraction during that test. In all the sprinters included, the subsequent MRI investigation had to confirm the suspected injury. Exclusion criteria were: verified or even suspected earlier hamstring strain in the same leg, extrinsic trauma to the posterior thigh (contusions), ongoing or chronic low back problems, pregnancy and total rupture or avulsion of one, two or all three hamstring muscles (determined by MRI).

Clinical examination

All the sprinters were tested on four occasions: two, 10, 21 and 42 days post-injury.

a) Palpation

Palpation of the rear thigh was performed with the sprinters prone and the knee extended. First, the origin of the hamstrings on the ischial tuberosity was identified. The sprinters were then asked to activate their hamstrings by performing an isometric contraction with manual resistance against the heel and no flexion at the knee. The palpation started approximately 5cm cranial to the hamstring origin and continued without interruption to the respective muscle insertions on the lower leg. The point where the subject noted the highest pain upon palpation was marked and the distance between this point and the palpated ischial tuberosity was measured.

b) Hip flexibility

The hip flexion test combined a passive unilateral straight leg raise test (SLR) with pain estimation according to the Borg CR-10 scale. The sprinters were placed supine with the pelvis and contralateral leg fixed with straps. A standard flexometer (Myrin®, Follo A/S, Norway, sensitivity 2o) was placed 10cm cranial to the base of the patella. The foot was plantar flexed and the investigator slowly (approximately $30^{\circ}.s^{-1}$) raised the leg with the knee straight until the subject estimated a 3 ("moderate pain") on the Borg CR-10 scale (0 = no pain and 10 = maximal pain). The hip flexion angle at this point was recorded, and the greatest angle of three repetitions was taken as the test result for range of motion (ROM). Values of the injured leg were expressed as a percentage of the uninjured leg for comparisons within and between groups. No warm-up preceded the flexibility measurements.

c) Knee flexion strength

Isometric knee flexion strength was measured with the sprinter in a prone position and the pelvis and the contralateral leg fixed. A dynamometer (Bofors KRG-4 T10®, Nobel Elektronik, Karlskoga, Sweden, range 0-4 kN) was placed at the ankle, perpendicular to the lower leg. The foot was in plantar flexion and the knee in an extended position. Three maximal voluntary isometric knee flexion contractions were performed, each with gradually increasing effort. Each contraction lasted three sec with 30 sec of rest in between. The highest force value was taken as the test result for strength. Values of the injured leg were expressed as a percentage of the uninjured leg for comparisons within and between groups. No warm-up preceded the strength measurements.

MRI investigation

The injured sprinters were to undergo four consecutive MRI investigations, at four, 10, 21 and 42 days after the incident of acute hamstring strain. All MRI investigations were performed on a 1.0 Tesla superconductive MRI unit (Magnetom Expert®, Siemens, Erlangen, Germany). The subjects were positioned supine on a commercial phased array spine coil. First, sagittal and frontal STIR images were obtained with a large field of view from at least 5cm above the ischial tuberosity to the knee. Then transversal, T1-weighted, T2-weighted, and STIR images were obtained covering the entire damaged area on the longitudinal images. Frontal and transversal images included also the uninjured side for comparisons at all four occasions. The thickness of the slices for all sequences was 5mm with a 0.5mm gap.

A muscle was considered as injured when it contained high signal intensity, as compared with the uninjured side, on the STIR images. A tendon tissue was considered as injured if it was thickened and/or had an intra-tendinous high signal and/or a collar of high signal intensity around it on the STIR images. Each injury was allocated to one or more of six different regions within the muscle-tendon complex. Particular attention was paid to whether the injury involved the proximal free tendon or not. The size of the injury was measured on the images as the maximal length (cranio-caudal extent), width (medio-lateral extent) and depth (antero-posterior extent). An attempt to estimate the volume of the injury was made by assuming that the injury had a shape of a rotational ellipsoid, i.e. volume U length x width x depth x 0.5.

The most cranial pole of the injury was identified and its cranio-caudal distance to the most caudal part of the ischial tuberosity was measured; hereafter this distance will be referred to as “distance to tuber”. The cross-sectional area of the injured muscle, as a percentage of the total cross-sectional area, was calculated at the level where the injury had the largest absolute cross-sectional distribution in the muscle.

Follow-up

On the first test occasion (two days after injury) each sprinter had to make a self-estimate of his/her time back to pre-injury level. They then all received the same standardised three-part progressive rehabilitation programme. The three parts were distributed at the first, second and third clinical examination, respectively. After the last examination, six weeks post-injury, continued rehabilitation was administered by the respective athlete’s physician and/or physical therapist. The subjects were asked to note the week when they could train or compete at their pre-injury level, i.e. competing at similar best-times. If re-injury occurred, the sprinters were to contact the main investigator (CA) immediately by phone. Follow-up contacts by phone were made by the main investigator at three, 12 and 24 months after the occurrence of the initial injury, and then any symptoms or problems from the previously injured hamstring muscle were noted.

Statistical analysis

In all cases the STATISTICA program, version 6.0, 7.0 and 8.0 (StatSoft®, USA) and SPSS program, version 11.0 and 15.0 (Statistical Package for the Social Sciences®, USA) were used for the analysis. The level of significance was set at $P < 0.05$ and tendencies were identified at $0.05 \leq P < 0.01$. Shapiro-Wilk’s W test was applied to examine normality in the distribution of data. To estimate the test-retest reliability of the hip flexibility test and the isometric knee flexion strength test, the values for the uninjured leg on the first and second test-occasions, eight days apart, were used to calculate the intra-class correlation (ICC) of the measurements with 95% confidence interval (CI). Repeated measures ANOVA with post-hoc Tukey test was used to detect statistical differences in ROM and strength over time. Spearman rank order correlation was calculated between subjects’ test results and time back to pre-injury level. Repeated measures ANOVA with post-hoc Tukey test was used to reveal statistical differences in MRI parameters over time. Pearson’s rank order correlation was calculated between the sprinters’ MRI parameters, palpation data and time to return to pre-injury level. Ethical approval was granted from the Ethical Committee of the Karolinska Institutet, Stockholm, Sweden[99-121].

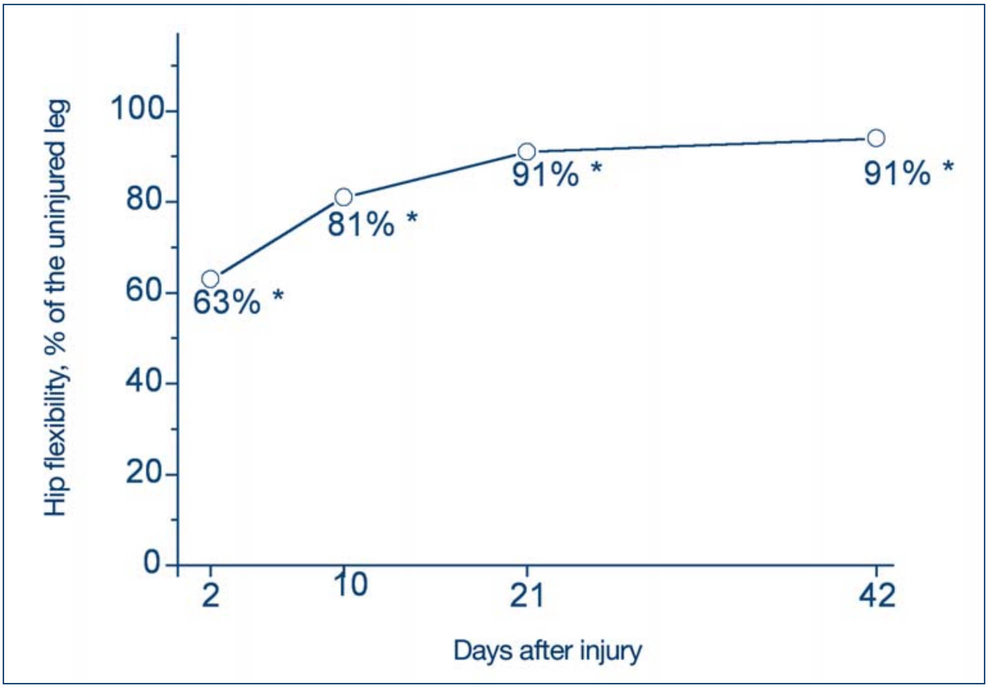

*Figure 1: Mean values for hip ROM of the injured leg compared with the uninjured leg in the sprinters (n = 18) at the four test occasions (*Denotes a significant difference (p < 0.05) between the injured and uninjured leg.*

Results

Clinical examinations

All 18 sprinters reported that they had encountered their injuries during competition sprinting when the speed was maximal or close to maximal. They were all forced to stop running directly when the injury occurred, and 11 of the 18 (61%) actually fell. At the initial examination (two days post-injury), 15 sprinters (83%) were using crutches. None of the sprinters reported any pre-injury symptoms, e.g. muscle stiffness or pain.

Upon palpation of the injury, all sprinters noted their highest pain in the lateral part of the rear thigh. The mean distances (±1SD, range) from the point with the highest pain to the ischial tuberosity at the four test occasions were: 12 (± 6, 5 – 24) cm, 11 (± 7, 3 – 24) cm, 12 (± 7, 4 – 24) cm, and 11 (± 8, 4 – 24) cm, respectively. The corresponding mean lengths (±1SD, range) of the painful area were: 11 (± 5, 5 – 24) cm, 7 (± 3, 3 – 11) cm, 6 (± 2, 4 – 9) cm, 5 (± 2, 2 – 8), respectively. At the last occasion (6 weeks post-injury), six subjects did not experience any pain upon palpation and were therefore not included in these calculations. There was a significant correlation between the location of the point of highest pain during palpation and time back to pre-injury level at clinical examination I ($r = 0.695$, $p = 0.004$) and III ($r = 0.680$, $p = 0.005$) and a tendency toward a correlation at examination II ($r = 0.503$, $p = 0.057$), i.e. the more cranial the location the longer the time back to pre-injury level. No correlation was present between the palpated length of the painful area and time back to pre-injury level. No ecchymosis was observed on the posterior thigh at any of the clinical examinations.

Table 2: Mean (SD) for ROM (degrees) for the hip flexibility test in the injured and uninjured leg in the sprinters (n = 18) at the four test occasions (I – IV) (Denotes a significant difference (p < 0.05) between the injured and uninjured leg.)*

	Injured	Uninjured
Test I	54 (16) *	88 (14)
Test II	71 (14) *	89 (15)
Test III	81 (14) *	90 (15)
Test IV	84 (15) *	90 (16)

a) Hip flexibility

The results from the sprinters showed a large decrease in range of motion (ROM) in hip flexion of the injured leg on the first test occasion (Figure 1, Table 2). Over the subsequent six weeks, the sprinters gradually recovered the ROM of their injured leg, but it was still significantly less on the last test occasion (Figure 1, Table 2). There was no correlation between the decrease of hip ROM in the injured leg at the first test occasion and time back to pre-injury level.

b) Knee flexion strength

The sprinters demonstrated significantly lower strength in the injured leg than in the uninjured leg on the first test occasion (Figure 2, Table 3). On the following test occasions this difference decreased gradually, but remained significantly decreased even at the last occasion (Figure 2, Table 3). There was no correlation between the decrease of knee flexion strength in the injured leg at the first test occasion and time back to pre-injury level.

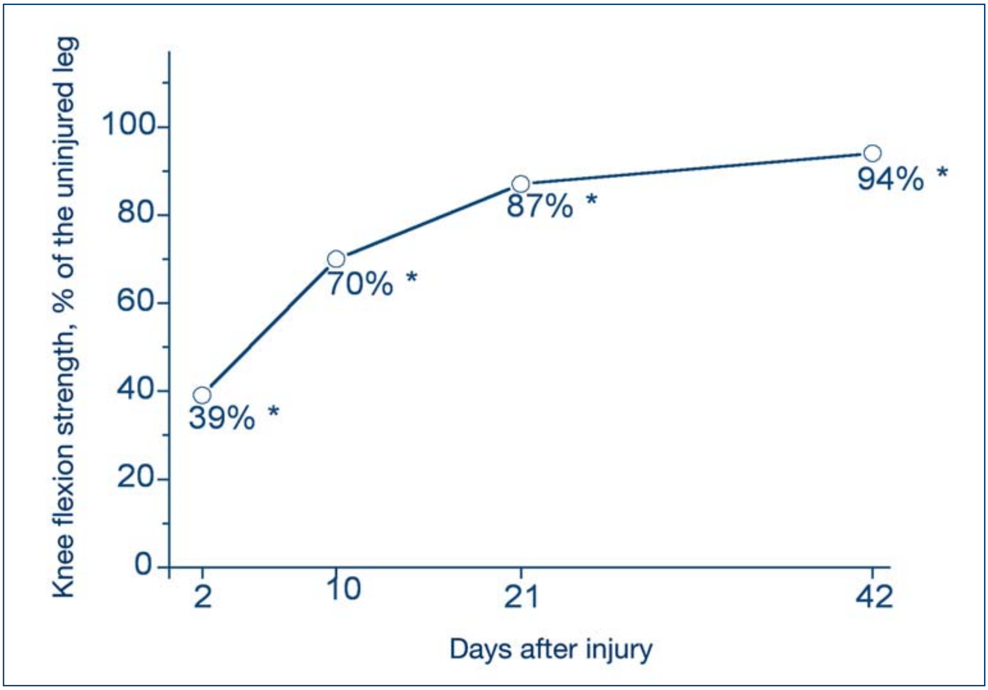

Figure 2: Mean values for knee flexion strength of the injured leg compared with the uninjured leg in sprinters (n = 18) at the four test occasions. (Denotes a significant difference (p < 0.05) between the injured and uninjured leg.)*

Table 3: Mean (SD) for strength (Nm) in the knee flexor strength test in the injured and uninjured leg in the sprinters (n = 18) on the four test occasions (I – IV) (Denotes a significant difference (p < 0.05) between the injured and uninjured leg.)*

	Injured	Uninjured
Test I	36 (15) *	95 (18)
Test II	66 (15) *	98 (20)
Test III	80 (25) *	93 (26)
Test IV	93 (19) *	102 (20)

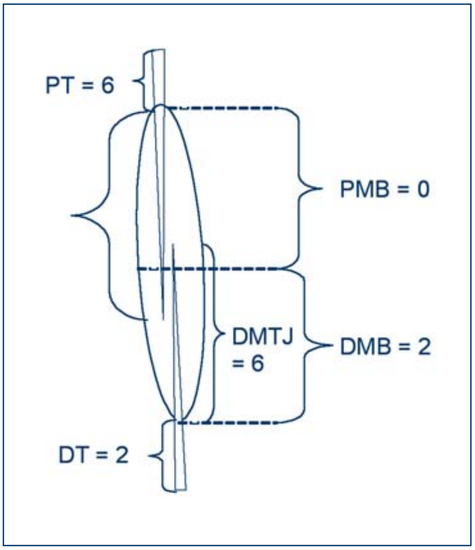

Figure 3: Number of sprinters with injuries in different muscle-tendon regions (PT, proximal tendon; PMTJ, proximal muscle-tendon junction; PMB, proximal muscle-belly; DMTJ, distal muscle-tendon junction; DMB, distal muscle-belly; DT, distal tendon)

MRI investigation

The actual times for the MRI investigations turned out to be close to those intended, i.e. four, 10, 20 and 42 days post-injury: the mean times (±1SD, range) being: 3.9 (±0.7, 2-5) days, 10.2 (±0.8, 9-12) days, 20.3 (±1.6, 18-24) days, and 42.8 (±2.8, 40-50) days, respectively.

No avulsion injuries or complete muscle or tendon ruptures were present and the x-ray of the pelvis was normal in all the sprinters. The long head of the biceps femoris muscle constituted the primary injury site in all 18 sprinters. Eight (44%) of the sprinters had a secondary injury, seven in the semitendinosus and one in the short head of the biceps femoris.

The location of the primary injury defined in relation to the different regions of the muscle-tendon complex of the long head of biceps femoris, is presented for each of the 18 sprinters in Figure 3. The subgroup where the injury involved the proximal free tendon of the long head of biceps femoris, PT, (n = 6) had a significantly longer time back to pre-injury level compared with the subgroup with no PT involvement (n = 12) (p = 0.009)(Figure 4).

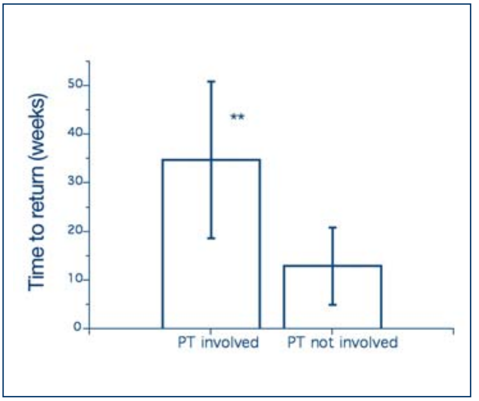

*Figure 4: Time to return to pre-injury level for the sprinters with injuries either involving the proximal free tendon (PT) of biceps femoris long head (n = 6) or not involving the PT (n = 12) (Values are means ±1 SD. ** denotes a significant difference between the two groups (p = 0.009, Mann-Whitney U test).)*

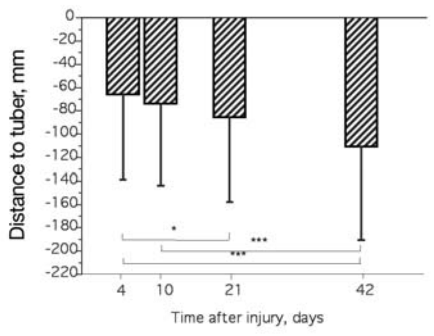

*Figure 5: Distance from the most proximal pole of the injury to the most distal part of the ischial tuberosity at the four MRI investigations (I-IV) (Negative values indicate that the injury is distal to the ischial tuberosity. Values are means -1 SD. Significant differences between MRI investigations (I – IV) are indicated; * p < 0.05, ** p < 0.01, *** p < 0.001.)*

There was a gradual increase in the distance from the most cranial pole of the injury to the ischial tuberosity with time after injury (Table 4, Figure 5). A similar change was seen for the disappearance of the injury as evidenced by gradual decreases of its length, width, depth, volume, and cross-sectional area from MRI investigation I to IV (Table 4). At the last MRI investigation, six weeks post-injury, the primary injury was completely healed, i.e. no signs of the injury appeared on MRI, in only one of the 18 sprinters. Correspondingly, six (75%) of the eight secondary injuries had disappeared at MRI investigation IV. The average size of the injury remaining after six weeks, as indicated by the measured MRI parameters, ranged 20-55% of the values at the first test occasion.

A clear majority of the calculated correlations (19/24) at the four MRI investigations demonstrated a significant positive relation-

Table 4. Mean values ± SD (range) for MRI-parameters at the four occasions (I – IV).

Parameter	MRI I (n = 17)	MRI II (n = 17)	MRI III (n = 15)	MRI IV (n = 18)
Distance to tuber, mm	67±71(-21-218)	79±65 (0-205)	86±69 (6-232)	102±79 (17-240)
Length, mm	187±74 (60-346)	159±64 (39-296)	144±81 (33-287)	90±60 (0-229)
Width, mm	22±10 (8-50)	18±6 (6-28)	18±8 (7-32)	12±6 (0-22)
Depth, mm	33±17 (8-66)	27±14 (7-57)	25±12 (9-48)	19±12 (0-44)
Volume, cm3	88±101 (4-414)	44±38 (8-109)	40±45 (1-161)	17±19 (0-67)
Cross-sectional area, %	38±23 (10-90)	32±19 (7-69)	26±16 (5-50)	17±15 (0-50)

Table 5: Correlations between MRI parameters at each of the four occasions (I – IV) and time to return to pre-injury level

MRI – parameters	MRI I (n = 17)		MRI II (n = 17)		MRI III (n = 15)		MRI IV (n = 18)	
	r	p	r	p	r	p	r	p
Distance to tuber	0.544*	0.044	0.599*	0.023	0.691**	0.006	0.705**	0.005
Length	0.505(*)	0.055	0.372	0.172	0.582*	0.023	0.726**	0.002
Width	0.394	0.146	0.384	0.158	0.423	0.116	0.186	0.507
Depth	0.584*	0.022	0.573*	0.025	0.662**	0.007	0.607*	0.017
Volume	0.608*	0.016	0.537*	0.039	0.716**	0.003	0.653**	0.008
Cross-sectional area	0.695**	0.004	0.636*	0.011	0.533*	0.041	0.463	0.082

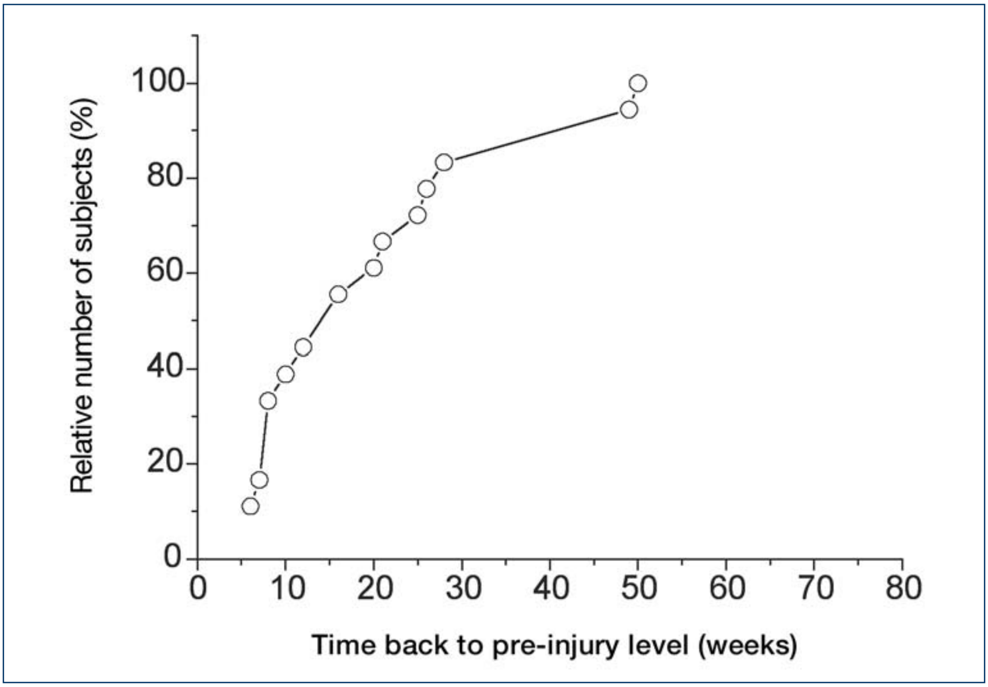

Figure 6: Relative number of sprinters, plotted against the time, in weeks, it took for each individual to return to pre-injury level of sprinting (n = 18)

ship between the various quantitative measures of the extent of the injury and the time to return to pre-injury level (Table 5).

Follow up

At the initial clinical examination (two days post-injury) the sprinters estimated that their time back to pre-injury level would be four weeks (median, range 2 – 12 weeks). However, the actual time back turned out to be significantly longer, the median value being 16 weeks (range 6 – 50 weeks) (Figure 6). At six weeks post-injury, all the sprinters could jog without pain, but only two (11%) were able to train and/or compete at their pre-injury level according to their own judgement. During the two-year follow-up, three sprinters (17%) encountered re-injuries of their hamstrings (at eight, nine and 20 months after their first-time injury, respectively) leading to a forced retirement from competitive sprinting for two of them. None of the sprinters had any other serious injuries during the two-year follow-up period.

Discussion

This study is the first to systematically characterise and follow up acute first-time hamstring injuries in sprinters. One major new finding was that the injury location in terms of distance from the ischial tuberosity was associated with time to return to competition; the more cranial the injury location, the longer the recovery time. Interestingly, the prediction of recovery time was equally good using the point of highest pain upon palpation, established within three weeks of the injury occasion, as using the distance from the most cranial pole of the injury determined with MRI. This indicates that repeated, carefully performed, clinical examinations during the first three weeks post-injury, can give important information about the prognosis of the hamstring strain. Furthermore, correlations existed at all MRI investigations, up to six weeks, which indicates that MRI is valuable for estimating recovery time even at a rather late stage of rehabilitation.

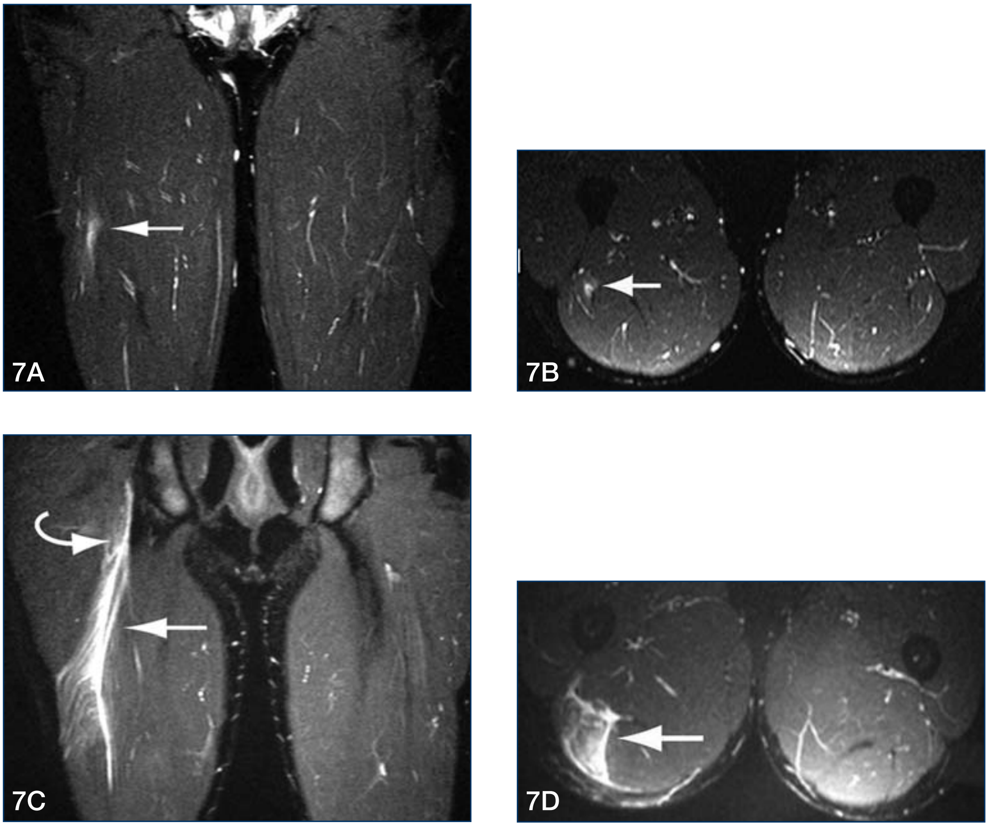

Figure 7A-D. Frontal (A,C) and transversal (B, D) MRI images (STIR) from the first MRI investigation four days post-injury; first (A,B), for the sprinter with the shortest time (6 weeks) and, second (C,D), the sprinter with the longest time to return to pre-injury level (50 weeks). In both, the injury was located in the long head of biceps femoris, involving, in the first sprinter (A) only a part of the PMTJ (arrow) and in the second sprinter (C) PMTJ (straight arrow) and PT (curved arrow). The values for selected MRI parameters in the first and second sprinters were: distance from the most cranial pole of the injury to the ischial tuberosity 107mm distal and 21mm proximal; length 60 and 251mm; volume 42 and 414cm3; and cross-sectional area 15 and 90%, respectively. The distance from the location of the highest pain upon palpation to the ischial tuberosity was 16 and 5cm caudal to tuber, respectively.

The other major new finding of the present study was that defining the region of injury within the muscle-tendon complex of the long head of biceps femoris was of significance for the prognosis of recovery time. Involvement of the free proximal tendon was associated with longer time to return to pre-injury level. This is in accordance with the results from the palpation, even though palpation evidently cannot distinguish between the tissues involved. No previous study on hamstring strains has systematically compared the consequences of involvement of free tendon versus muscle/muscle-tendon junction on recovery time. In recent studies on hamstring strains in dancers[3] and athletes in different sports,[4] including sprinters, we have clearly shown that an involvement of the proximal free tendon is associated with a prolonged time to return to sport.

Our findings of good prediction of recovery time for the sprinters from the size and/or the position of the injury in relation to the ischial tuberosity (more or less cranial) as well as proximal tendon involvement are illustrated by the two extreme cases within our material shown in Figure 7 (data on each individual are presented in the figure legend). For the sprinter with the shortest time back (six weeks) (Figure 7A and B), the size of the initial injury was small and the distance to the ischial tuberosity was long compared to the sprinter with the longest recovery time (50 weeks) (Figures 7C and D). The latter had an injury involving the proximal free tendon, whereas the former did not. Interestingly, these two sprinters showed very similar initial symptoms, both fell dramatically during their races and had to use crutches for four days post-injury. Also, isometric knee flexion strength and range of motion in hip flexion with straight knee showed a similar decrement at the first clinical examination in the two sprinters (remaining strength in % of the uninjured leg: 47% vs 53%, range of motion 80% vs 64%, respectively). At the last test, six weeks post-injury, the values for the two sprinters were: remaining strength 87% vs 101%, range of motion 96% vs 70%, respectively. The sprinter with the shortest time back was healed at the last MRI investigation, but the sprinter with the longest time back still had 64% left of the length of the injury at the last MRI investigation.

Specificity of the material and the injuries

This study was carried out on a well-defined injury in a specific group of athletes. Strict inclusion criteria resulted in a rather small group of subjects, albeit a three-year study period, but, on the other hand, in a homogenous group with acute, first-time hamstring strain injuries of similar aetiology. All the sprinters that were included in the study after the initial clinical examination had their hamstring injury verified by the MRI. Careful history ensured that the injury was a true first-time injury, which disqualified a majority of potential subjects. All the sprinters studied had a very specific injury situation, namely straightforward, undisturbed, competitive running at maximal or close to maximal speed. Thus the conditions were well controlled, with respect to, e.g., running surface, shoes, fatigue, and warm-up. Although this study was limited to sprinters, it should be possible to extrapolate the results to other events in athletics, where hamstring injuries are considered to occur frequently at high running speed.

All primary injuries were located in the long head of biceps femoris. This result on sprinters is in line with previous studies showing that this is the most commonly injured hamstring muscle in high force/high speed sports.[5,14] Our observation that seven of the eight secondary injuries occurred in the semitendinosus muscle is also in accordance with earlier studies on other types of athletes reporting a combined injury of biceps femoris and semitendinosus as the most common “tandem injury”.[5,16] The reason for the predominance of hamstring strain injuries in these particular parts of the hamstring muscle synergy is not known. Anecdotal evidence from moderate speed uphill running[10] and biomechanical modelling of high speed running[19] suggest that the long head of the biceps femoris should be the muscle undergoing the most lengthening when activated at the end of the swing phase and/or early support phase in fast running. But, for obvious reasons, systematic data on the actual injury mechanism are lacking.

Although various methods have been applied to classify which regions and tissues in the muscle tendon complex that are injured[7,18] most studies agree that the muscle-tendon junction is involved.[9,13,18] Of importance in this context is to acknowledge the complex anatomy of the hamstring muscles with well-defined free tendons and extensive intramuscular tendons.[8,21] The present study shows that in the sprinters the free tendons are also affected by the injury.

Progression of the injury - status after six weeks

The acute effects of the injury were conspicuous. At the first clinical examination, two days post-injury, 15 of the 18 sprinters used crutches and isometric knee flexor strength and range of motion in hip flexion with straight knee were markedly reduced.[1] Remaining strength and flexibility amounted to 38% and 61%, respectively, of that of the un-injured leg. However, the recovery was remarkably fast. Already ten days after the injury, none of the sprinters needed crutches during walking, and strength and flexibility were back to more than 70% of the values for the uninjured leg. After six weeks, the performance of the injured leg in the strength and flexibility tests exceeded 90% of that of the uninjured leg, but only two sprinters considered themselves ready to run at maximal speed. Thus, a 90-95% level of test performance, an often recommended criterion for full return to sports, was not in agreement with the sprinters´ own judgement that they could return safely to maximal speed running.

No ecchymosis was observed in any of the clinical examinations and, accordingly, the MRI investigations showed that the injuries were mainly located intra-fascially. All the sprinters experienced pain upon palpation at three weeks, but one third of them were pain-free at six weeks. Notably, only one of these six pain-free cases completely lacked MRI indications of injury at this time. In general, there was good agreement between the results of palpation and the MRI findings. The palpation results showed consistency in locating the point of highest pain, and the MRI analysis demonstrated that this point fell within the longitudinal extent of the injury in 85% of all cases at all four test occasions. The point of highest pain was always located in the lateral part of the rear thigh, which is consistent with the MRI signs of injury primarily situated in the long head of the biceps femoris muscle.

One of the limitations of our study relates to control of the rehabilitation during the follow-up period. After the first six weeks the rehabilitation of the subjects was trusted with their own physicians and physical therapists, and therefore there was a possibility of varying methods being employed. However, all subjects in this study came from a similar high competition level, having daily access to sport physicians, sports physical therapists, and coaches. These rehabilitation teams have corresponding levels of education and training, and thus are likely to apply similar treatment and rehabilitation programmes for hamstring strains. Thereby, the potential influence of varying rehabilitation procedures on the current results should be minimized.

Conclusions

Careful palpation during the first three weeks post-injury and MRI investigation during the first six weeks post-injury provide useful information on time to return to the pre-injury level of performance in elite sprinting. This type of information is essential for medical personnel and coaches, in order to make a realistic judgement of the injury, the duration of the recovery time, and the risk for re-injury –all for the benefit of the athlete.

Recommendations

- Take all acute hamstring strains seriously - underestimation is too common
- The acute decrease of function says nothing about the recovery time
- Be careful after 4-10 days post-injury when the symptoms decrease
- Palpation pain close to the ischial tuberosity – red flag
- MRI can confirm the severity of the injury during a long period after the occurrence
- MRI showing that the proximal free tendon is involved - red flag

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