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Reinjury After Acute Posterior Thigh Muscle Injuries in Elite Track and Field Athletes

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Investigation performed at the National Track & Field Centre, Sports Injury Clinic, Thessaloniki, Greece

Background: Hamstring muscle strains often recur. The authors studied the effect of the grade of initial injury on the subsequent risk of reinjury.

Hypothesis: No difference in reinjury rate between acute low-grade (grades I and II) and high-grade (III and IV) hamstring muscle strains would be seen.

Study Design: Cohort study (prognosis); Level of evidence, 1.

Methods: Between 1999 and 2007, the authors managed 165 elite track and field athletes with acute, first-time unilateral hamstring muscle strains. Strains were classified into 4 grades (I, II, III, and IV) based on knee active range of motion deficit at 48 hours. The same rehabilitation protocol was prescribed, and the rate of reinjury was recorded during the following 24 months.

Results: The average time to return to sport after initial injury was 7.4 days for grade I injuries, 12.9 days for grade II injuries, 29.5 days for grade III injuries, and 55.0 days for grade IV injuries. At follow-up, 23 of the 165 athletes (13.9%) had experienced a second hamstring muscle strain. Of the 75 athletes with a grade I injury, 7 (9.3%) had experienced a recurrence after 24 months. Of the 58 athletes with a grade II injury, 14 (24.1%) experienced a recurrence. Of the 26 athletes with a grade III injury, 2 (7.7%) experienced a recurrence, and of the 6 athletes with a grade IV injury, none had experienced a recurrence after 24 months.

Conclusion: Low-grade hamstring muscle lesions appear to lead to a higher risk of reinjury than high-grade hamstring muscle lesions. However, there were disproportionately fewer high-grade injuries than low-grade injuries. Objective clinical findings can accurately determine the risk of reinjury after acute hamstring muscle strains in elite track and field athletes.

Keywords: hamstring strain; classification criteria; recurrence rate; reinjury; athlete; sports

Muscle strains of the posterior thigh muscles, collectively known as the "hamstring" muscles, are common.[4,5,22,33] They are frequently injured during activities such as high-speed running when they are required to contract eccentrically at high velocity.[25,33,34] Other mechanisms of injury include slow stretching at an extreme range of motion such as during ballet dancing[2] or a traumatic incident such as a fall during water skiing.[23,32] Prevalence rates for hamstring injuries have been reported between 12% and 16% for different sports including English professional soccer, Australian Rules professional football, and track and field athletics.[4,22,33]

The biarticular nature of the hamstring muscles has been suggested as a possible reason for the predisposition to muscle strain injury.[21] This is supported by the observation that other muscles spanning 2 joints, such as the rectus femoris, gastrocnemius, adductor longus, and adductor magnus, are also frequently strained during sporting activity.[21] Hamstring injuries can lead to prolonged absence from sport, and lengthy rehabilitation.[3,7,17,18,23] In addition, reinjury rates can be as high as 34% after 1 year.[22] Several studies have shown that a reduction in the rate of reinjury can be achieved by correcting eccentric strength deficits,[1,5,7,8,11] performing progressive agility and trunk stabilization exercises during the rehabilitation period,[25] and correcting adverse neural tension with neural stretches and mobilization.[14,27]

Several factors increase the risk of reinjury. Some are irreversible, such as previous hamstring injury,[9,12,30,31] age,[9,30,33] race (black or aboriginal descent),[30,33] fatigue,[11,28,33] and a larger size or length of lesion on MRI.[29] The main reversible risk factors are poor eccentric hamstring strength[1,7,8] and, to a lesser extent, the presence of adverse neural tension.[14,27] Adverse neural tension is diagnosed by a positive response to slump testing and indicates that a neural component to reinjury risk may be

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present.[27] The presence of adverse neural tension has been associated with recurrent low-grade hamstring injuries.[14,27] Treatment with a regimen of "slump stretches" has been reported to lead to resolution of symptoms,[27] but a subsequent reduction in reinjury risk has not yet been demonstrated. Of these factors, only MRI appearance is presently known to be a direct consequence of the initial injury and can therefore provide specific prognostic information at the time of the initial injury.[6,10,26,28] Hamstring strains that at MRI scanning show no pathological features have been associated with previous back injury, and are also associated with earlier return to sport.[10,28,30] However, ultrasonography is equally useful at identifying hamstring muscle injuries and may be preferable because of lower costs.[6] Using MRI to predict recovery and the risk of reinjury after acute hamstring muscle strains may therefore be impractical outside of the research setting or the management of high-level professional athletes.

We recently conducted a prospective study of 165 elite track and field athletes with first-time, acute hamstring muscle strains. We found a correlation between reduced knee active range of motion (AROM) and increased severity of injury, which was demonstrated by a longer period of time to return to full training or competition. The reduction in knee AROM was measured objectively, using a plastic hand-held goniometer. We grouped these injuries into 4 grades, based on the AROM deficit between healthy and injured limbs at 48 hours. As a result, we were able to produce a classification system to accurately predict the speed of recovery after acute hamstring muscle strains.[17] This classification system was based on the AROM deficit alone, without the need for further investigations such as ultrasonography or MRI, although all athletes initially underwent ultrasonographic assessment to confirm that a muscular lesion was present. We further hypothesized that this classification system could provide an inexpensive clinical tool to predict the risk of reinjury. The aim of this study was to investigate whether clinical assessment, including measurement of AROM deficit at 48 hours, can provide an early indication of the risk of reinjury after acute hamstring strains in elite track and field athletes.

MATERIALS AND METHODS

All procedures undertaken in this study were approved by the Ethics Committee of the Greek Track and Field Federation, and all participating athletes gave their written informed consent to participate in the study. Between 1999 and 2005, we diagnosed and managed 260 elite track and field athletes with an acute, first-time posterior thigh muscle injury sustained during training or competition. During this period, we managed 1269 lower limb injuries in total. Posterior thigh muscle injuries accounted for approximately 20% of all lower limb injuries.

Eligibility Criteria

All athletes were examined by a single board-qualified sports medicine physician following detailed history taking. During clinical examination, the following signs were elicited: (1) local tenderness on palpation at the injured site, (2) pain with resisted movements (knee flexion, hip extension), and (3) pain with passive flexion of the hip with the knee extended.

Athletes were included in the study if all of the above symptoms were present, suggesting an acute hamstring muscle injury. In addition, all athletes initially underwent ultrasonographic assessment to confirm that a muscle lesion was present. Exclusion criteria included uncertain clinical diagnosis based on the above criteria, bilateral injuries, a verified or previously suspected posterior thigh muscle injury, extrinsic trauma to the posterior thigh, pain on palpation at the origin or insertion of the posterior thigh muscles, tendon avulsion or total rupture of any or all of the hamstring muscles, chronic low back pain, sciatica, and pregnancy.

From a total of 260 athletes (150 male, 110 female; age range, 18-25 years) with a suspected hamstring muscle strain who were initially examined, 165 athletes (97 male, 68 female; age range, 18-24 years) were included in the study. These athletes participated in different track and field disciplines (Table 1). Ninety-five athletes were excluded according to our eligibility criteria (Table 2).

TABLE 1
Discipline of the Injured Athletes

Event	No. of Athletes
Sprint	75
Middle/long distance	13
Long/triple jump	39
Throws	15
Combined events	23
Total	165

Classification System

We used a previously described 4-grade classification system to grade all injuries.[17] According to this system, an objectively measured deficit in knee AROM is used to accurately predict the likely recovery time and thus severity of injury (Table 3). The reduction in knee AROM was measured goniometrically and compared with the uninjured side. The athlete lay supine with the uninjured lower extremity fully extended and the examined extremity positioned at 90° of hip flexion. A clear 30-cm, double-arm plastic goniometer was used (Lafayette Instrument Company, Lafayette, Indiana) (Figure 1). The center of the goniometer was placed on the lateral knee joint line superficial to the lateral femoral epicondyle, with the stable arm parallel to the greater trochanter and the movable arm parallel to the lateral malleolus (Figure 2). The difference in AROM measurement between the healthy and injured side was expressed as the "AROM deficit." This measurement has previously been shown to be valid and reproducible, with no difference in AROM found in healthy control athletes.[17]

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TABLE 2
Details of Excluded Athletes

Reason for Exclusion	No. of Athletes
Extrinsic trauma to posterior thigh	8
Tendon avulsion or complete rupture	2
Concurrent low back pain	14
Sciatica	2
Bilateral injury	3
Postexercise muscle soreness	18
Tendon injury at origin or insertion	15
Previous anterior cruciate ligament reconstruction using semitendinosus autograft	5
Previous posterior thigh muscle injury	27
Pregnancy	1
Total	95

TABLE 3
Classification System for Acute Hamstring Strains With Average Recovery Time[a]

Clinical Grade	AROM Deficit	FRT, days
I	<10°	6.9 (2.0)
II	10°-19°	11.7 (2.4)
III	20°-29°	25.4 (6.2)
IV	≥30°	55.0 (13.5)

[a]AROM, active range of motion (knee); FRT, full rehabilitation time.

Management During the First 48 Hours

When hamstring injury was suspected after initial assessment, the injured athletes were managed with the PRICE protocol (pain relief, rest, ice, compression, and elevation) for the next 48 hours. Ice was applied for 15 minutes every hour for the first 6 hours after the examination, and subsequently every 3 hours. The thigh was compressed using an elastic bandage and was kept elevated. No motion was allowed for the first 6 hours, and isometric exercises of the periarticular muscles of the hip and knee were encouraged thereafter, with AROM exercises and weightbearing within pain limits.

Clinical Evaluation at 48 Hours

All athletes were re-evaluated 48 hours after the initial injury. This evaluation included (1) palpation of the posterior aspect of the thigh with the athlete prone, to elicit tenderness if present; (2) provocation of pain on isometric contraction of the posterior thigh muscles; (3) provocation of pain on passive hip flexion with the athlete supine; and (4) measurement of AROM deficit as described above.

Rehabilitation Protocol

All included athletes with a clinically diagnosed hamstring muscle injury followed the same standardized rehabilitation program and their progress was supervised by experienced physiotherapists.[18]

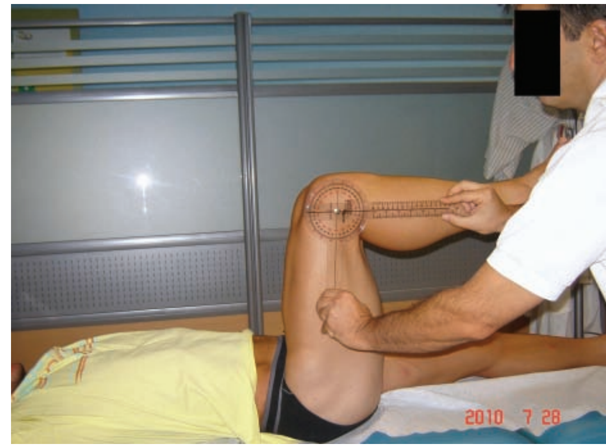

Figure 1. Knee extension goniometry: positioning of the goniometer.

Figure 2. Knee extension goniometry: positioning of the goniometer and measurement technique.

Follow-up

Athletes were followed up weekly in the clinic during their rehabilitation program and their return to high-performance activities was recorded. The follow-up period lasted until the athletes returned to full, pain-free sporting activity. Each athlete was asked to record the first week that they trained or competed at their preinjury level without any symptoms or signs of injury (such as pain, swelling, and/or tenderness). In addition, the following objective criteria were used to determine return to full sporting activities: (1) normalization of AROM deficit, (2) isokinetic hamstring strength deficit of less than 5% measured at 60 deg/s and 180 deg/s compared with the injured side, and (3) no difference in single-legged triple hop test.

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TABLE 4
Grade of Initial Injury and Risk of Reinjury

Clinical Grade	No. of Athletes	Percentage	No. Reinjured	Percentage Reinjured
I	75	45.4	7	9.3
II	58	35.2	14	24.1
III	26	15.8	2	7.7
IV	6	3.6	0	0

The latter was used as the final criterion for return to full athletic activities, and we refer to this time interval from the initial injury as the full rehabilitation time.

All athletes remained under constant surveillance, and were monitored through regular face-to-face contact with the senior author (Dr Malliaropoulos). This was in addition to telephone contacts with the athletes and their coaches at 1, 3, 6, 12, 18, and 24 months after injury. Any recurrence of acute posterior thigh symptoms was immediately recorded, and the athlete was evaluated and managed accordingly. The final rate of reinjuries was calculated after 24 months.

Statistics

Data were entered in a commercially available database, and analyzed using SPSS for Windows, version 8.0 (SPSS, Inc, Chicago, Illinois). The χ^2 test and 1-way analysis of variance were used. The multiple-comparisons Scheffé test was used to analyze the effect of reinjury on return to sport according to the grade of injury. We used the Cox proportional hazards survival regression analysis to determine the effect of the grade of injury on the time between the original injury and reinjury, the time between return to sport and reinjury, and the time to return to sport after reinjury. Significance was set at $P < .05$.

RESULTS

We followed up all 165 athletes. Seventy-five athletes experienced a grade I injury, 58 athletes experienced a grade II injury, 26 athletes experienced a grade III injury, and 6 athletes experienced a grade IV injury (Table 4). At 24-month follow-up, 23 of our 165 athletes (13.9%) had experienced another acute hamstring muscle strain. In our series of 165 consecutive elite track and field athletes, we found no recurrence of hamstring strain in athletes with a grade IV injury.

Grade I Injury

Of the 75 athletes who experienced a grade I injury, 7 (9.3%) suffered a recurrence after 24 months of follow-up. Two athletes were reinjured once, 2 were reinjured twice, 1 reinjured 3 times, and 2 reinjured 4 times. The average time between the first injury and return to sport was 7.4 ± 1 days. The average time between original injury and reinjury was 5.1 ± 6.3 months. The average time between return to sport and reinjury was 4.8 ± 6.3 months. The new posterior thigh injury was of the same grade in 3 athletes and more severe (grade II) in 4 athletes. The time to return to sport after reinjury was 9.3 ± 1.1 days.

Grade II Injury

Of the 58 athletes who experienced a grade II injury, 14 (24.1%) had suffered a recurrence after 24 months of follow-up. Seven athletes were reinjured once, 5 were reinjured twice, 1 reinjured 3 times, and 1 reinjured 4 times. The average time between the first injury and return to sport was 12.9 ± 1 days. The average time between original injury and reinjury was 4.7 ± 6.3 months. The average time between return to sport and reinjury was 4.3 ± 6.3 months. The new posterior thigh injury was of the same grade in 7 athletes and less severe (grade I) in the other 7 athletes. The time to return to sport after reinjury was 17.4 ± 2.1 days.

Grade III Injury

Of the 26 athletes who experienced a grade III injury, 2 (7.7%) had suffered a recurrence after 24 months of follow-up. Both were less severe (grade II) injuries. The average time between the first injury and return to sport was 29.5 ± 3.5 days. The average time between original injury and reinjury was 3.5 ± 0.6 months. The average time between return to sport and reinjury was 2.6 ± 0.5 months. The time to return to sport after reinjury was 33.5 ± 4.9 days.

Grade IV Injury

Of the 6 athletes who experienced a grade IV injury, none had experienced a recurrence after 24 months of follow-up. The average time between the first injury and return to sport was 55.0 ± 13.5 days.

The χ^2 test showed a significant difference in the rate of reinjury between athletes with different grades of injury (P = .003). In particular, athletes with a grade II injury experienced a significantly higher risk of reinjury (24.1%) than those with a grade I injury (9.3%) (P = .009). Also, athletes with a grade II injury experienced a higher rate of reinjury than those with a grade III injury (7.7%)

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(P = .005). There was no significant difference in the rate of reinjuries between athletes who suffered a grade I injury (9.3%) and those who suffered a grade III injury (7.7%) (P = .808).

Regarding the time between original injury and reinjury, 1-way analysis of variance did not reveal any significant differences ($F_{2,20}$= .047; P = .954) between athletes with different grades of injury. For grade I, the value was 5 ± 6.2 months (95% confidence interval [CI], –0.76 to 10.70); for grade II, 4.6 ± 6.1 months (95% CI, 1.09 to 8.19); and for grade III, 3.49 ± 0.64 months (95% CI, –2.30 to 9.27). Cox proportional hazards survival regression analysis also showed no significant differences regarding the time between original injury and reinjury in athletes with different grades of injury. The grade of injury did not contribute to the time between original injury and reinjury (χ^2 = .022; P = .989), although athletes who experienced a grade II and a grade I injury have a greater potential for reinjury.

There was no difference in the time between return to sport and reinjury when considering the various grades of injury ($F_{2,20}$= .104; P = .902) (grade I: 4.9 ± 6.4 months, 95% CI –1.03 to 10.81; grade II: 4.4 ± 6.4 months, 95% CI 0.69 to 8.05; grade III: 2.6 ± 0.5 months, 95% CI –2.28 to 7.51). Cox proportional hazards survival regression analysis confirmed this finding, as the grade of injury did not contribute to the time between return to sport and reinjury (χ^2 = .105; P = .949), although athletes who experienced a grade II and a grade I injury have a greater potential for reinjury.

However, the grade of injury exerted a significant effect on the time to return to sport after reinjury ($F_{2,20}$= 109.191; $P < .05$). The multiple-comparisons Scheffé test showed that athletes who experienced a grade III injury took longer to return to sport after reinjury (33.5 ± 4.9 days; 95% CI, –10.97 to 77.97) than athletes who experienced a grade II injury (17.4 ± 2.1 days; 95% CI, 16.24 to 18.62) and those who experienced a grade I injury (9.3 ± 1.1 days; 95% CI, 8.26 to 10.31). Cox proportional hazards survival regression analysis confirmed this finding: the grade of injury contributes to the time to return to sport after reinjury (χ^2 = 31.274; $P < .05$), and athletes who experienced a grade I injury showed a shorter time to return to sport after reinjury.

DISCUSSION

In this study, we report a relationship between the grade of acute posterior thigh muscle strain and the risk of reinjury in elite track and field athletes. We used a validated classification system to grade each injury into 1 of 4 grades of severity. We then followed each injury for 24 months to determine the risk of recurrence.

The major strengths of this study are its prospective nature, the fact that clinical examination was always performed by the same fully trained sports medicine physician, and that all athletes were followed for 24 months. We chose a follow-up period of 24 months to ensure that the results of management had stabilized and a full recovery had been made. Also, previous studies have reported that certain risk factors for reinjury only become apparent during the second year after the initial injury.[12,29] All the athletes included in this study were strictly supervised to ensure that they completed the prescribed rehabilitation program. Our strict inclusion criteria ensured that only athletes with a clinically confirmed, acute first-time presentation of posterior thigh muscle strain were included. Similarly, our assessment procedure allowed us to exclude athletes with complete tendon or muscle ruptures who were possible candidates for operative management.[13,16,24,32] Our complete follow-up and the number of athletes included make the results of this study directly relevant to clinical practice.

We believe that classifications based on criteria such as pain and ability to bear weight are limited by their subjective nature. We used a validated classification system based on objective and reproducible measurements that are easily performed in the clinic setting. Clinical, ultrasonographic evaluation and AROM measurements were performed 48 hours after the initial injury to allow a partial recovery of lower severity injuries. We thought that in the acute setting, immediately after the injury, significant pain and disability are present and attempts to accurately determine the athlete's knee AROM would be unreliable.

This study was conducted in elite track and field athletes. Although our results may well be applicable to other sports, especially those with a similar mechanism of injury (ie, running and jumping), we acknowledge that this is not necessarily the case. Future studies could aim to validate our classification system in different sporting populations to determine whether its predictive value is maintained. Similarly, our study was conducted on well-motivated, high-level athletes, and we can only speculate that recreational athletes would behave in a similar way. Again, this could be the aim of future research. Ninety-five athletes were excluded according to our eligibility criteria. The most common reason for exclusion was a previous posterior thigh muscle injury, which is the main predisposing risk factor for posterior thigh muscle injuries generally.

In our prospective study of 165 hamstring injuries in elite track and field athletes, we found the incidence of grade IV injuries to be small, at only around 4% (n = 6) of all hamstring injuries. Furthermore, no athletes who suffered a grade IV injury subsequently suffered a reinjury. However, as there were only 6 athletes in this group, we are fully aware that the power of this observation is low. Our findings may not be generalizable to cohorts with a high proportion of grade IV injuries that require greater than 55 days of rehabilitation. This could also be the subject of future research.

It is difficult to compare the findings of our study with previous research, as we are unaware of any other studies reporting the use of a classification system for acute hamstring muscle strains to determine the risk of reinjury.

High-level athletes often demand faster rehabilitation: The typical scenario is of an athlete seeking a precise diagnosis and a definite indication of the time necessary to return to full sporting activities. Magnetic resonance imaging scans can accurately depict the anatomy and extent of damage to the posterior thigh muscles and may be of prognostic value, especially if they are negative.[10,28,30]

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However, they are also expensive, and do not provide precise information about the risk of reinjury.[10,15] Also, clinical evaluation can be more accurate than MRI in predicting recovery time, and clinical findings alone may be sufficient to predict recovery time.[17,25] Imaging may therefore only be indicated for suspected completed muscle or tendon ruptures.[16,32] The method outlined in the present study, when combined with close follow-up and adequate rehabilitation, enables the clinician to establish with some degree of certainty the likely recovery time and subsequent risk of reinjury.

This investigation shows that elite track and field athletes with first-time acute posterior thigh strains experience a significant difference in their risk of reinjury according to the severity and grade of their initial injury. Athletes who suffered a grade II injury experienced a significantly greater risk of reinjury (24.1%) compared with those who suffered a grade I injury (9.3%). On the other hand, there were no significant differences in the rate of reinjury between athletes who suffered a grade I injury (9.3%) and those who suffered a grade III injury (7.7%). One-way analysis of variance did not reveal any significant differences between different grades of injury and the time taken between the original injury and reinjury. The same was true for the time between return to sport and reinjury. However, the grade of the original injury exerted a significant effect on the time to return to sport after reinjury. Athletes who suffered a grade III injury took longer to return to sport after reinjury than athletes who experienced a grade I or grade II injury. Even though both grade III recurrences were less severe grade II injuries, the time taken to return to sport (33.5 days) was markedly longer than that taken to return following first time-grade II injuries (12.9 days). However, given the small numbers of athletes is this group (n = 2), no firm conclusions can be drawn about this observation. Furthermore, the design of the present study does not enable us to determine why this should be the case. We cannot conclude that these athletes did not take their reinjury more seriously. It is also possible that these athletes put more attention and efforts into their rehabilitation program following reinjury.

We cannot offer biomechanical explanations that may account for the difference in the rate of reinjury in athletes with different grades of injury. Our data on time to return to sport suggest that athletes with more severe injuries experience a longer rehabilitation time. One possibility is that athletes with low-grade injuries (grades I and II) believe that their hamstring strain is less severe, and return to sport too soon. It is also possible that, despite being able to perform the activities that permit progression through the different stages of rehabilitation, optimum functional outcome had not been achieved and a subsequent residual risk of reinjury remained after rehabilitation. Finally, we cannot rule out that some athletes performed additional rehabilitation exercises of their own volition, in addition to the supervised rehabilitation program that was prescribed. Again, the design of this study does not allow us to accept or firmly discard these possible explanations.

It has previously been suggested that the risk of reinjury after muscle strains cannot be completely eradicated.[19,20] However, in the present study, the highest rate of reinjuries was seen after grade II strains. These injuries correspond with a recovery time of approximately 12 days, and are therefore considered relatively minor. It can be argued that this group of athletes in particular may benefit from an attempt to identify any reversible risk factors that may further increase their risk of reinjury in addition to their initial strain. These athletes may potentially benefit from a longer period of rehabilitation or a more cautious approach to their return to sporting activities. We accept that it is presently unknown whether this would reduce the rate of reinjuries and that such an approach would need to be balanced with the possible disadvantage of an increased rehabilitation time. It has been recognized, however, that there is currently a lack of scientific evidence to support return-to-play decisions,[20] and therefore this could be the subject of future studies.

In conclusion, we found that a classification system based on easily measured objective clinical findings was able to accurately assess the risk of reinjury after acute first-time hamstring muscle strains in elite track and field athletes.[17] Grade II injuries experienced the greatest risk of recurrence and were significantly more likely to recur than grade I and III injuries. In general, low-grade (grades I and II) injuries were more likely to recur than high-grade (grades III and IV) injuries. However, overall there were few high-grade injuries, which may have had a significant bearing on the rate of reinjuries in this group. The classification system used in this study can provide an effective clinical tool to assess the risk of reinjury after acute hamstring muscle strains in elite track and field athletes.

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