Hamstring injuries: prevention and treatment—an update

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ABSTRACT

Despite increased knowledge of hamstring muscle injuries, the incidence has not diminished. We now know that not all hamstring injuries are the same and that certain types of injuries require prolonged rehabilitation and return to play. The slow stretch type of injury and injuries involving the central tendon both require longer times to return to play. A number of factors have been proposed as being indicators of time taken to return to play, but the evidence for these is conflicting. Recurrence rates remain high and it is now thought that strength deficits may be an important factor. Strengthening exercise should be performed with the hamstrings in a lengthened position. There is conflicting evidence regarding the efficacy of platelet-rich plasma injection in the treatment of hamstring injuries so at this stage we cannot advise their use. Various tests have been proposed as predictors of hamstring injury and the use of the Nordboard is an interesting addition to the testing process. Prevention of these injuries is the ultimate aim and there is increasing evidence that Nordic hamstring exercises are effective in reducing the incidence.

INTRODUCTION

In spite of all the research and additional understanding of hamstring muscle injures over the past 20–30 years, we have not reduced the incidence of first-time injuries and the recurrence rate is still extremely high. While research published over the past couple of years has led to an increased understanding of these challenging injuries, we still have a long way to go in the management of hamstring muscle injuries.

NOT ALL HAMSTRING INJURIES ARE THE SAME

We now understand that certain types of hamstring injuries are more likely to require prolonged rehabilitation and delayed return to play (RTP). Askling *et al*[1–3] has proposed two distinctly different types of acute hamstring strains, one occurring during high-speed running and mainly involving the biceps femoris long head, the other during movements leading to extensive lengthening of the hamstrings (such as high kicking, sliding tackle, sagittal split) often involving the free proximal tendon of semimembranosus. He demonstrated that injuries of the slow stretch type, while initially appearing less severe than the sprinting type of injury, actually have a prolonged RTP.[1–4]

In addition, muscle tendon architecture may be a factor in the development of hamstring injuries. Rehorn and Blemker,[5] using a three-dimensional model, initially suggested that the aponeurosis morphology of the biceps femoris long head (BFLh) may play a significant role in determining stretch distributions throughout the muscle. Others have suggested that variability of aponeurosis widths may be important in determining muscle injury susceptibility.[6] Studies have suggested that a relatively small[7 8] or narrow[9] proximal aponeurosis of the BFLh may be predictive of hamstring injury.

This may explain why injuries involving the central tendon have been shown to be associated with prolonged RTP.[10] MRI has enabled us to visualise the intramuscular component of the tendon.

A number of us have for many years promoted the concept that the mild hamstring injury, often presenting as a 'cramp' or 'twinge' or 'feeling of impending tearing', is not due to a hamstring muscle injury, but due to referred pain from the lumbar spine, fascial injury or gluteal trigger points. Now with the advent of MRI showing minimal or no local muscle damage in these cases, the so-called MRI-negative hamstring injury, there has been broader acceptance of this phenomenon and appropriate treatment initiated with resulting early RTP.[11 12]

WHAT DETERMINES RTP?

There are a number of factors that have been suggested as good indicators of severity and prolonged time to return to play. Askling *et al*[3] suggested that the closer the lesion was to the ischial tuberosity the longer the time to RTP. While a relationship between proximity to the ischial tuberosity and time to RTP makes sense based on anatomical knowledge (ie, likelihood to involve tendon), it is worth noting that a recent review[12] found some conflicting evidence. Of the four studies performed to date, three studies reported a significant association between a shorter distance to the ischial tuberosity and a longer time to RTP,[3 13 14] whereas one study found no association.[2]

The same review[12] also evaluated the relationship between the size of the hamstring injury lesion on MRI, including the length, cross-sectional area and signal volume, and the time to RTP. The review concluded that there was no strong evidence from any MRI finding that can guide radiologists and sports physicians in predicting prognosis for the time to RTP after an acute hamstring injury. Similarly there was no correlation of ultrasound findings with time to RTP.[15]

In a study comparing clinical and MRI indicators of RTP,[16] the clinical parameters of self-predicted time to RTP (TTRTP) and passive straight leg raise deficit were independently associated with the TTRTP. The latter contradicted the findings of two previous studies.[4 17] MRI parameters in grade 1 and 2 hamstring injuries were not associated with TTRTP. It was, therefore, suggested that for clinical

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practice, prognosis of the TTRTP in these injuries should be based on key clinical parameters.

RECURRENCE

Reinjury after RTP remains a major problem. It is more common when the injury involves the biceps femoris.[11] The number of previous hamstring injuries, active knee extension deficit, isometric knee flexion force deficit at 15°, and presence of localised discomfort on palpation just after RTP are also associated with a higher hamstring reinjury rate.[18]

There is increasing evidence that even after RTP, eccentric hamstring strength is reduced, which may be a factor in the high recurrence rate of these injuries.[19–25] Earlier studies failed to show any differences.[26 27]

Whereas studies by Silder *et al*[28] and Emami *et al*[29] have failed to show any difference, Opar *et al*[30] demonstrated that previously injured hamstrings displayed lower rate of torque development (RTD) and early contractile impulse (IMP) during slow maximal eccentric contraction compared with the contralateral uninjured limb. Lower myoelectrical activity was confined to the biceps femoris long head.

Regardless of whether these deficits are the cause of or the result of injury, these findings could have important implications for hamstring strain injury and reinjury. Particularly, given the importance of high levels of muscle activity to bring about specific muscular adaptations, lower levels of myoelectrical activity may limit the adaptive response to rehabilitation interventions and suggest that greater attention be given to neural function of the knee flexors after hamstring strain injury.

It has been suggested that the cause of this eccentric weakness is prolonged neuromuscular inhibition at long muscle lengths after hamstring muscle injury.[31] Pain-driven neuromuscular inhibition of hamstring voluntary activation occurs following hamstring strain injury, and this inhibition has a detrimental effect on hamstring recovery by limiting hamstring exposure to eccentric stimuli at long muscle lengths during rehabilitative exercise.[31]

Mendiguchia *et al*[32] examined the effects of an acute hamstring strain injury on sprinting performance, and mechanical properties of sprint running at the time of return to sport and 2 months later. The study showed that despite being cleared to play, soccer players returning from a recent hamstring injury had substantial lower sprinting speed performance and reduced mechanical horizontal properties compared to the uninjured players. The greater magnitude differences in horizontal force compared to maximum velocity suggested that the lower maximal horizontal power observed in the injured player was mainly related to the reduced maximal horizontal force component. Approximately 2 months of regular soccer training after return to sports resulted in substantial improvements in sprinting speed (acceleration) concomitant with an increase in maximal horizontal force and power, whereas the speed component and top speed remained unaltered.

The limited exposure to eccentric stimuli could potentially produce several maladaptations observed following hamstring injury, including chronic eccentric hamstring weakness,[20 31 33 34] selective hamstring atrophy[35] and shifts in the torque joint-angle relationship.[26] Timmins *et al*[36 37] recently demonstrated shorter biceps fascicle length and increased pennation angle as well as reduced eccentric strength in previously injured hamstrings.

IMPLICATIONS FOR CLINICAL MANAGEMENT

What are the implications of this research for clinical practice? Perhaps more emphasis should be placed on reduction of pain in the early days after hamstring injury to reduce the neuromuscular inhibition associated with pain, while at the same time encouraging early muscle activation, particularly eccentric exercise at longer muscle lengths, and early return to running with rapid progression to high-speed running.

While the concept of eccentric muscle training as an important component of the rehabilitation process has been with us for many years, it now appears that these exercises must be in the lengthened position. This makes sense when you think that the majority of hamstring muscle injuries are located in the long head of biceps femoris, a muscle that straddles both the hip and knee joints. The standard leg curl exercise, therefore, does not work the long head sufficiently. As a result, lengthening eccentric exercises such as the Nordic hamstring exercise (NHE),[38 39] the Romanian dead lift and Askling's 'extender', 'diver' and 'glider' exercises[13] are now becoming the mainstay of postinjury rehabilitation.

Two papers have proposed parameters by which hamstring rehabilitation programmes can be created. Malliaropoulos *et al*[40] suggested the following parameters—injury mechanism, hip or knee dominant, location, targeted muscle, length rather than strength, training parameters—should be considered when devising a rehabilitation protocol.

Guex and Millet[41] suggested a conceptual framework for strengthening exercises for hamstring muscles specific to the terminal swing phase of sprinting based on six key parameters (contraction type, load, range of motion, angular velocity, unilateral/bilateral exercises, kinetic chain) for strain prevention. They advocated that in sprinting sports, high-load eccentric contractions should be performed at a slow to moderate angular velocity and focused at the knee joint, while the hip is kept in a large flexion position (80°) in order to expose the hamstrings to a greater elongation stress than occurs in the terminal swing phase. They postulated that as a result, during sprinting, athletes would be better trained to brake knee extension effectively in the whole range of motion without overstretch of the hamstrings.

They also advocated unilateral open kinetic chain exercises based on their functional application. After analysing some of the frequently used hamstring strengthening exercises, they came to the conclusion that the 'optimal exercise had not been designed yet'. Finally, they noted that strain prevention is not only a question of strength, but also depends on the timing of contraction, or a combination of both.

REHABILITATION PROGRAMMES

For a number of years the only RCT comparing different hamstring rehabilitation programmes was Sherry and Best[42] study, which reported significantly lower reinjury rates in athletes who completed a progressive agility and trunk stabilisation (PATS) programme, compared to those whose rehabilitation programmes focused on isolated hamstring strengthening and stretching.

Silder *et al*[14] demonstrated a similar degree of muscle recovery at the time of return to sport in patients with an acute hamstring strain injury treated with either the PATS programme or a programme with a heavy emphasis on eccentric strengthening (PRES).

Askling *et al*[13] performed two identical studies, one in footballers and other in sprinters and jumpers,[43] and demonstrated that a rehabilitation protocol consisting of mainly lengthening type of exercises (L-protocol) is more effective than a conventional protocol in promoting return to sport after acute hamstring injury. The most conspicuous characteristics of the more successful L-protocol were the systematic attempts to put load on the hamstrings during maximal dynamic lengthening, using exercises entitled The Extender, The Diver and The Glider. On this basis, they recommended that hamstring injury rehabilitation protocols should be preferentially based on strength and flexibility exercises that primarily involve exercises with high loads at long muscle–tendon lengths.

IS THERE A ROLE FOR PLATELET-RICH PLASMA?

The use of autologous blood injections, such as platelet-rich plasma (PRP) has become widespread in recent years, primarily in the treatment of chondral and tendon problems. Recently the first two high-quality studies have been published examining the use of PRP in muscle injuries. Two studies produced conflicting results.

Using a double-blind, randomised and multicentre approach, Reurink *et al*[44] recruited 80 recreational athletes with hamstring muscle strain injuries, and infiltrated the injured area with either isotonic saline or a standardised formulation of PRP. Ultimately, the authors found no statistical or clinically significant difference in either of their key outcome measures, RTP duration and reinjury rate, leading them to conclude that PRP is no more effective than a placebo injection of saline.

Hamid *et al*[45] compared a group who received a PRP injection along with a standard rehabilitation programme with a control group who received the rehabilitation programme alone and found that patients in the PRP group achieved full recovery significantly earlier than controls. Significantly, lower pain severity scores were observed in the PRP group throughout the study. They concluded that a single autologous PRP injection combined with a rehabilitation programme was significantly more effective in treating hamstring injuries than a rehabilitation programme alone.

Of the two studies, the Reurink paper is of substantially higher quality with its use of a placebo saline injection. Previous PRP studies using saline as placebo[46 47] have also failed to confirm the improvements found in those studies without placebo. There is not at this stage sufficient evidence to advocate the use of PRP in acute muscle injuries.

CAN WE PREDICT HAMSTRING INJURY?

Previous attempts to develop a tool to predict the likelihood of hamstring injuries have been based on isokinetic testing.[48] More recently, other tests have been proposed.

Freckleton *et al*[49] demonstrated a significant deficit in preseason single leg hamstring bridge (SLHB) scores on the right leg of players who subsequently sustained a right-sided hamstring injury. Age, previous knee injury and a history of hamstring injury were other risk factors supported in this study.

Shield and Opar have designed a test, the Nordic board test, to measure hamstring strength based on the NHE. Their study[50] demonstrated that (1) the experimental device showed high to moderate test–retest reliability for measurements when the NHE was performed bilaterally, but poor reliability during unilateral testing, and (2) elite athletes with a unilateral history of hamstring injury within the previous 12 months displayed significant eccentric knee flexor weakness in their injured limb compared to their uninjured limb and to the limbs of uninjured recreational athletes.

Hamstring weakness in Australian rules footballers demonstrated on the Nordic board test was associated with increased risk of hamstring injury. Higher Nordic hamstring strength offset the risk of increasing age and previous hamstring injury.[51]

Another study[52] examined hamstring strength measured with a hand-held dynamometer and distance achieved in a single leg hop test. They found that lower maximum eccentric hamstring strength, higher isometric/eccentric hamstring strength ratio, and a lower score on the Sydney Local Health District (SLHD) test were significant risk factors for a subsequent hamstring injury.

Finally, in a case report, Schache *et al*[53] looked at the use of regular clinical monitoring of hamstring strength during a season in football players with a history of hamstring strain. It was concluded that measuring postgame hamstring isometric maximal voluntary contraction asymmetry on a weekly basis may be helpful in identifying adverse reactions to load (ie, inhibition, presence of symptoms, or both) that could represent early warning signs for hamstring strain susceptibility.

It is clear that we are some distance away from being able to predict hamstring muscle injury. Many of the issues highlighted by Mendiguchia in his 2012 *BJSM* paper[54] remain unresolved. The inter-relationships between the various possible risk factors need to be examined more fully.

CAN WE PREVENT HAMSTRING INJURIES?

Prevention is better than cure and there is evidence that a programme of eccentric hamstring exercises, such as the yo-yo curl[55] or NHE,[38 56–59] can reduce the incidence of hamstring muscle injuries.

The recommended NHE programme[38] of three sessions per week during a 10-week preseason programme and subsequently, one session a week has been incorporated in the training regimes of many football clubs. An Italian study[60] demonstrated reduced injuries in an amateur football club using the FIFA 11+ injury prevention programme with addition of NHE.

CONCLUSION

While there has been significant additions to the literature over the past couple of years, we have still not managed to reduce the incidence of hamstring muscle injuries. Further high-quality research is needed.

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