

Hamstring Injuries

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Introduction

Muscular strains of the lower limb are among the most common injuries in sport. They make up one third of all referrals to sports physicians ¹ and their frequency and disabling effect is well documented ². Hamstring injuries in particular are the most common type of muscular strain to affect the lower limb in the elite athlete ³. They are associated with sports which involve rapid acceleration or deceleration, jumping, cutting, pivoting, turning or kicking. They are particularly associated with Australian Rules Football (AFL) ⁴ rugby and soccer. They result in significant time off sport, can be the source of considerable pain and can result in impaired performance on return to activity.

Mechanism of Injury

The hamstrings function primarily by eccentric contraction to decelerate forward progression of the tibia during the swing phase of gait. Eccentric contraction is more efficient than concentric contraction. It requires less oxygen but the tension generated during eccentric contraction is much higher than with concentric, generating higher intrinsic forces within the muscle and hence predisposing to injury. Disruption results in loss of normal eccentric control.

Hamstring tears do not result from direct trauma but rather are stretch induced injuries caused by a sudden forced lengthening occurring during a powerful contraction. The most common mechanism of injury is ballistic hip flexion during eccentric knee extension.

Factors predisposing to injury:

Several factors have been implicated in the aetiology. These are poorly supported by scientific evidence.

1. Previous injury

Orchard in a prospective study reviewed 2255 games of AFL ⁴. Previous injury to the hamstrings was shown to be the most significant risk factor. He also showed that history of a recent hamstring injury predisposed to a subsequent quadriceps or hamstring injury.

2. Fatigue

In animal studies, muscle fatigue has been shown to predispose to injury. One study has demonstrated that in the hind leg of the rabbit fatigued muscles absorb less energy in the early stages of stretch when compared with non-fatigued muscle ⁷. Fatigued muscle also demonstrates increased stiffness, which has been shown to predispose to subsequent injury. It is thought that this is partly due to altered biomechanics which may be protective to the injured muscle but detrimental to adjacent uninjured muscle.

3. Reduced Flexibility / Stiffness

Decreased flexibility has also been shown to have a significant association with hamstring injury. Many authors have emphasised the importance of warm up prior to activity and of maintaining flexibility. Muscle that is cyclically stretched demonstrates an increased ability to increase length prior to failure. A decrease in muscle stiffness is also seen with warming up ⁷.

A study by Witvrouw et al⁸ found a strong correlation between preseason hamstring tightness and subsequent hamstring injury in soccer players. A further study by Jonhagen et al⁹ looked at the association between reduced flexibility and hamstring injury in sprinters. They compared the flexibility of the hamstrings and the eccentric and concentric muscle torque in the posterior and anterior compartments of the thigh in injured and non-injured sprinters. They concluded that sprinters with a history of previous injury had significantly tighter hamstrings.

Laboratory studies have shown the importance of stiffness and the need for stretch and warm up. The hamstrings are viscoelastic and therefore exhibit the property of stress relaxation. That is by increasing the length of the musculotendinous unit, there is a reduction in strain. Garrett⁷ showed in the rabbit model that with a simulation of warm up by stretching muscle isometrically and then stimulating, there was increased stretch prior to failure.

4. Weakness

Many studies have shown that poor strength is associated with hamstring injury. Jonhagen⁹ showed that uninjured sprinters had significantly higher eccentric hamstring torques at all angular velocities. They also had weaker concentric contractions at low velocities.

Orchard et al¹⁰ carried out a prospective study looking at preseason weakness in AFL players. They found a strong correlation with subsequent hamstring injury and have since introduced protocols looking at hamstring to quadriceps and hamstring to contralateral hamstring, muscle strength ratios. If a player is found to have preseason weakness they undertake a strengthening programme and are retested.

Recurrence

This common injury has a high incidence of recurrence which makes it one of the most frustrating for players, coaches, treating doctors and physiotherapists. Orchard has shown a recurrence rate of 30.6% for the remainder of the season in AFL players¹⁰. Animal studies⁷ have shown that an incomplete disruption to the myotendinous junction causes the muscle to be more susceptible to injury.

A further possible cause for recurrence includes alteration to normal biomechanics. The resulting scar tissue has a reduced tensile strength and is therefore more susceptible to strain injury. The scar is also stiffer than normal tissue and therefore causes reduced range of motion. Furthermore, with a prior injury there is also a loss of strength in other muscle groups due to disuse.

As mentioned above the healing process has been shown to be more prolonged than initially thought¹². Although the vast majority of re-ruptures occur in the first week on return to activity, there is a significant risk of recurrence for many weeks after return to play¹³.

Anatomical Site

The hamstring muscles make up the posterior compartment of the thigh. They are bi-articular in that they cross both the hip and knee joints. They comprise biceps femoris, semimembranosus and semitendinosus. The long head of biceps takes its origin from the Ischial tuberosity in conjunction with semitendinosus and semimembranosus. The short head of biceps takes its origin from the linea aspera. Distally the biceps inserts into the lateral aspect of the fibular head and the medial hamstrings insert into the medial aspect of the proximal tibia via the pes anserinus. Their primary function is to act as flexors of the knee and hip extensors. They also facilitate in rotation of the knee.

Several studies have shown that the most common site for hamstring injury is in the biceps femoris at the myotendinous junction. At the microscopic level the injury disrupts the myotendinous junction at the Z line between adjacent thin filaments.

An elegant study by Garrett ¹¹ with Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) has shown that the lesion is most commonly found in the long head of biceps, proximally and laterally. He went on to state that the muscles most susceptible to a strain injury are those which cross 2 joints (biceps femoris, gastrocnemius, rectus femoris) or those with a more complex architecture such as the adductor longus.

The injury can be seen on MRI / CT to occur at the myotendinous junction, supporting the laboratory models (Figure 2). The lesion is not localised to one focal area as there is extensive altered signal within muscle which is remote from the site of injury. High signal can also be seen tracking around the epimysium and surrounding neurovascular structures on T2 weighted MR images ¹¹.

A study by Verrall ⁵ et al also showed biceps femoris to be the most common site of injury. They further found that injuries occurring in the lower third were less common and less painful than those occurring in the proximal or middle thirds. However they went on to show there is no difference in site of injury and number of missed days from sport.

Pathophysiology

Despite extensive investigation the aetiology and pathophysiology of these injuries remains unclear. Histological studies have shown that the lesion is characterised by inflammation and oedema and to a lesser extent bleeding¹². Although there is initial bleeding after rupture of the fibres, this is followed by an acute inflammatory response, with proliferation of fibroblasts. As the inflammatory process resolves a fibrotic process follows leading to scar formation.

On a molecular level there is initially an up-regulation of type 3 collagen mRNA rather than type 1. There is also relatively poor expression of Myosin mRNA which extends to the protein level where type 3 collagen is present prior to any myofibril regeneration¹³. The resultant scar is weaker and stiffer than uninjured tissue. This may account for the high recurrence rate of this injury and also for the fact that the healing process occurs over a more prolonged period than was initially thought ¹³.

Clinical Presentation

Clinically hamstring injuries are usually characterised by a history of a sudden onset of posterior thigh pain associated with localised tenderness and loss of function. On examination there may be localised swelling, tenderness and possibly a palpable defect. Ecchymosis is highly indicative of a significant injury. (Figure 1.) Athletes with chronic injuries often describe a feeling of tightness or an impending “pull”. There is pain on resisted knee flexion when prone with decreased strength. There is also a reduced straight leg raise when compared with the uninjured side.



Figure 1. Ecchymosis following proximal injury and visible muscle defect with contraction.

The clinical features can be more insidious with poor localisation of pain. Verall et al ⁵ looked at 83 AFL players prospectively over 2 seasons and found 9% of presenting injuries to be insidious in nature. Where the diagnosis is not clear-cut, the differential includes: minor contusions, posterior compartment syndrome or referred pain from the lumbar spine, gluteal region, piriformis or sciatic nerve.

Classification

The most widely used grading system of injury is that devised by O'Donoghue ⁶. This is related to the violence of the injury and the subsequent amount of tissue damage that follows.

- Grade 1 or 1st Degree. There is no appreciable tissue disruption, no loss of function or strength and there is only a low-grade inflammatory response.
- Grade 2 or 2nd degree.
Actual tissue damage occurs that reduces the strength of the musculotendinous unit. There is some residual function.
- Grade 3 or 3rd degree
This is characterised by complete disruption of the musculotendinous unit with complete loss of function.

Imaging

Ultrasound and CT are useful modalities but the gold standard for assessing these injuries is MRI. This is particularly useful in minor hamstring injuries or where the diagnosis is equivocal. Once the correct diagnosis has been made the patient can then be started on an appropriate tailored rehabilitation programme.

MRI has further corroborated laboratory studies which have localised the injury to being at or near the musculotendinous junction. (Figure 2.)

A study by Gibbs et al ¹⁴ looked at the ability of MRI to predict recovery and recurrence from grade 1 hamstring injuries in AFL players. This prospective study showed a strong correlation between the length of the lesion and recovery time. However it did not show a close correlation with risk of recurrent injury.

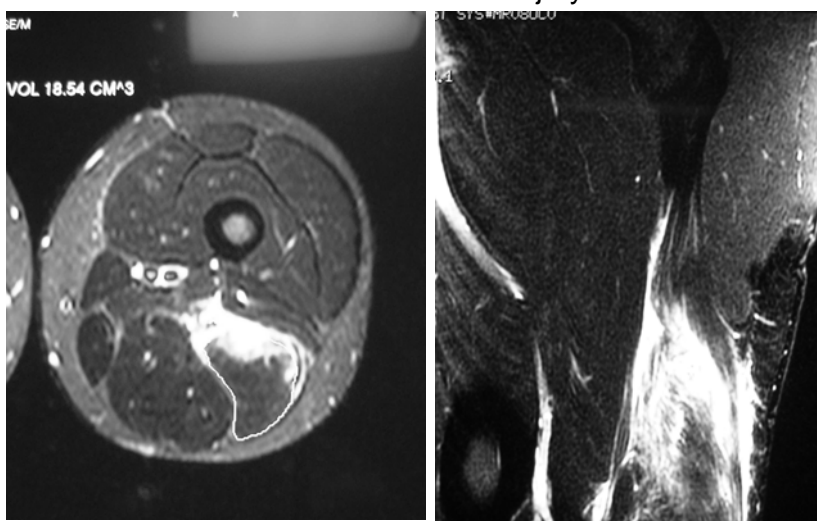


Figure 2. MRI images showing proximal biceps femoris musculotendinous injury.

Treatment

The management of these common injuries is essentially activity modification together with a tailored rehabilitation programme. Other non-operative measures include the use of non-steroidal anti-inflammatory medication, intramuscular injection of corticosteroid, electrical stimulation and ultrasound. Surgery is occasionally indicated where there is complete avulsion.

1. Non-steroidal Anti-inflammatory medication

Non-steroidal anti-inflammatory drugs (NSAIDs) are frequently used following muscle strain injury. Their role has been questioned¹⁵ in that they may slow the healing response and recovery of normal tensile strength of the injured musculotendinous unit.

2. Corticosteroid injection

The use of steroids is also controversial for fear of poor healing, rupture or infection. The vast majority of sports medicine practitioners do not advocate the use of corticosteroid injection in the management of these injuries.

Levine et al¹⁶ carried out a retrospective study reviewing NFL players between 1995-98 who had sustained hamstring injuries. 431 players were included. The indication for steroid injection was a severe discrete injury with or without a palpable defect. 58 (13 %) players were treated with injection. They reported no complications and only 9 players (16%) missed any games as a result of their injury. They recommended the use of steroid injection in selected patients as a means of returning to normal activity quicker with less missed time off sport.

3. Ultrasound

Although frequently used, the role of ultrasound in these injuries is poorly supported by scientific evidence. Studies have shown that low frequency ultrasound increases the tensile strength of healing bone following fracture, healing tendon and soft tissue in general¹⁷.

Ultrasound is thought to act by causing a localised increase in temperature. This results in an increase in protein synthesis and membrane permeability and also increases fibroblast activity. A study by Rantanen et al¹⁸ looked specifically at the role of ultrasound and at myoregeneration in simulated muscle strain injury in vivo and found no evidence of enhanced muscle regeneration.

4. Surgery

Surgical intervention although rarely indicated in the management of these injuries does have a role where there has been complete avulsion of the proximal hamstrings. This is a soft tissue injury with avulsion from the lateral aspect of the ischium. Occasionally a bony avulsion of the ischium occurs and this may require internal fixation.

The diagnosis is difficult and as a result often made late. The patient presents with posterior thigh pain, massive swelling and ecchymosis. Clinical examination may demonstrate localised tenderness, swelling and asymmetry due to distal retraction of the avulsed muscle belly. Weakness and a visible defect are demonstrated by active resisted contraction of the hamstrings whilst the patient lies prone. The investigation of choice is MRI.

The literature shows that these injuries are associated with significant morbidity and do not do well with non-operative treatment^{18,22}. In a retrospective review of 11 patients by Kliengele et al²⁰, good results were reported with reconstruction in both acute and chronic injuries. The indication for surgery was complete avulsion or in the chronic situation where the patient had persisting weakness or pain.

Rehabilitation

Initial management consists of RICE (rest, ice, compression and elevation) to minimise further tissue damage, reduce further bleeding, settle the acute inflammatory response and control pain. This is followed by a period of gentle range of motion exercises including

seated active knee extensions. Simple analgesics and NSAIDs can be used. Early motion promotes healing, and minimises scar formation.

The next phase involves stretching which initially is done passively and through a limited range. Early strength work can be started as tolerated with specific exercises including hamstring curls, bridges, flicks and dead lifts.

Finally, straight-line running is encouraged gradually working up to more rapid acceleration and deceleration drills. Sports specific training follows and when ready the athlete can return to sport.

It is widely accepted that the average muscle strain will resolve over a 2-3 week period. Heiser et al ¹⁵ carried out a retrospective review of 46 primary hamstring injuries in collegiate American football players. They noted an average convalescence period of 2 weeks before return to full activity.

Many protocols have been established but most consist of the following 5 phases with regular clinical assessment to determine whether treatment can be accelerated or needs to be slowed down.

Phase 1

RICE with assessment of severity of injury. Progression to the next phase is guided by initial response to treatment.

Phase 2

Early motion with protective exercise and passive stretching. Initially isometric type exercise is encouraged at whatever range is comfortable and continued with 20 degree increments. Isotonics are then commenced with the introduction of resistance work. Swimming and upper body workouts are encouraged for general conditioning and tailored according to severity of injury and symptoms.

Phase 3

Isokinetic exercises are then introduced. For ongoing conditioning, the use of an exercise bike and treadmill are encouraged. Flexibility is assessed at regular intervals with the hip flexed to 90 degrees and the knee maximally extended.

Phase 4

Once the athlete can perform slow isokinetic exercises comfortably, a running programme is introduced. This allows eccentric work of the hamstrings. The intensity of training is gradually increased and the athlete begins agility work and sprinting.

Phase 5

The final phase of the rehabilitation is return to sport. There is no consensus as to when an athlete can return to sport after sustaining a hamstring injury. Every effort is made to mimic the specific sporting activity and if this can be done pain free, with normal strength, full agility and no focal tenderness, then return to full activity is allowed. In spite of this, the risk of recurrence remains high for a significant period of time.

Conclusion

The management of hamstring injuries remains difficult and frustrating. Prevention is the ultimate goal however there is no consensus or gold standard as to how this is best achieved. Several studies have shown that pre-participation warm up, repetitive stretching, adequate conditioning to reduce fatigue and proper technique can reduce the risk of injury.

The risk of re-rupture is high at 30% for AFL players and the risk remains for many weeks following the index injury. New methods of assessment have been introduced to look specifically at preseason weakness and this has been useful to identify those at risk of a further injury.

As a rule return to activity is guided by the functionality of the athlete. However the clinician needs to convey caution following hamstring injury, as the risk of a further injury remains high even in the absence of any residual symptoms.

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