PREVENTING HAMSTRINGS STRAINS

A CURRENT VIEW OF THE LITERATURE

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Muscle injuries occur frequently as contusion injuries in contact sports and as strains in sports involving maximal sprints and acceleration. Among sprinters, hamstring strains represent approximately 1/3 of all acute injuries[1]. Since the different football codes (soccer, rugby, American football, Australian Rules football) combine maximal sprints with frequent player-to-player contact, it is not surprising that a sizable proportion of injuries are thigh injuries. In fact, recent studies from the professional level show that hamstring strains alone rank as the first or second most common injury in soccer[2-5], Australian Rules football[6,7], rugby[8,9] and American football[10,11], in most studies accounting for one in every five to six injuries. There also appears to be a trend with a gradual increase in the proportion of hamstring strains compared to other injury types such as ankle sprains when compared to data from studies from the 1980s[12]. However, it should be noted that quadriceps strains are also common in soccer[4] and that muscle contusion injuries to the quadriceps muscles account for a significant proportion of all football injuries at the elite level. Hamstring strain injuries are also common in sports where the muscles may be stretched past the usual range of movement (ROM) e.g. dancing and water-skiing[13].

> *Studies show that hamstring strains rank as the 1st or 2nd most common injury in soccer*

Risk Factors for Hamstring Strains

Well documented:

- *Previous hamstring strain.*
- *Age (older players at higher risk).*
- *Low hamstring muscle strength.*

Less well-documented:

- *Low hamstring muscle flexibility.*
- *Low quadriceps muscle flexibility.*
- *Race (black players and players of Aboriginal descent at greater risk).*
- *Gender.*
- *High level of play.*
- *Insufficient warm-up.*
- *Muscle fatigue.*
- *Player position.*

INJURY MECHANISMS

There are two main mechanisms involved in thigh muscle injuries:

1. Direct (contusion) injuries.
2. Indirect (distension or strain) injuries.

The contusion mechanism is straightforward. The player is typically injured by a direct blow from an opponent, usually the knee hitting the lateral thigh in a tackle (a.k.a. 'charley horse' or 'cork thigh'). The muscle is thereby crushed between the opponent's kneecap and his own femur.

The injury mechanism for hamstring strains are less well understood. The hamstrings muscle group is composed of three muscles:

1. Semimembranosus
2. Semitendinosus
3. Biceps femoris.

All of them (except the short head of the biceps) have their origin at ischial tubercle on the pelvis and they insert at the inside and outside of the lower leg right below the knee. This means that they overlap two joints – they straighten the hip joint and bend the knee joint. Muscle strains usually occur in the interface between the muscle and its tendon (the myotendinous junction), but avulsion injuries from the ischial tubercle are also seen.

Hamstring strains most often occur during maximal sprints. It is difficult to document exactly at what time during the running cycle injuries occur[14]. However, since the net moment developed by the hamstrings is thought to be maximal in the late swing phase, right before heel strike, this is thought to be a vulnerable position[15,16]. In this instance, the hamstring muscles work eccentrically. Another suggestion is at push-off. Strain injuries to the quadriceps muscles have been less studied, but are thought to mainly result from kicking the ball.

RISK FACTORS

A number of candidate risk factors have been proposed for hamstring strains, the most prominent being the following four internal factors (see Text Box 1):

1. age,
2. previous injury,
3. reduced hip ROM and
4. poor hamstrings strength[17].

In theory, limited ROM for hip flexion could mean that muscle tension is at its maximum when the muscle is vulnerable close to maximum length. However, this hypothesis has yet to be confirmed, since there are several studies on soccer players suggesting that hamstring flexibility is not a risk factor for strains[18,19]. However, other studies from soccer and Australian Rules football have shown low quadriceps flexibility to represent a risk factor for not only hamstrings[20], but also quadriceps strains[21].

Low hamstring strength would mean that the forces necessary to resist knee extension and start hip extension during maximal sprints could surpass the tolerance of the muscle-tendon unit. Hamstring strength is often expressed relative to quadriceps strength as the 'hamstrings: quadriceps ratio', since it is the relationship between the ability of the quadriceps to generate speed and the capacity of the hamstrings to resist the resulting forces that is believed to be critical. Several studies show that players with low hamstring strength or 'low hamstrings: quadriceps strength' ratio or 'side-to-side strength imbalances' may be at increased risk of injury[17].

A history of previous hamstring strains greatly increases injury risk, as documented in numerous studies[17,22,23]. Injury can cause scar tissue to form in the musculature,

> ***There is convincing evidence of a substantial protective effect of this exercise programme***

resulting in a less compliant area with increased risk of injury. A previous injury can also lead to reduced ROM or reduced strength, thereby indirectly affecting injury risk. Football players with a history of previous hamstring injury have a seven times higher risk of injury than healthy players and as many as 13% can expect to suffer a new injury during one season.

Older players are at increased risk for hamstring strains. Although older players will be more likely to have a previous injury, increased age is also a risk factor independent of a history of previous injury[19,23].

Other risk factors, which have been suggested but are less well-studied, include:

- race,
- gender,
- level of play,
- player position,
- improper running technique,
- superior running speed (peak performance),
- low back pain,
- increases or changes in the training programme (particularly intense periods of training),
- insufficient warm-up and
- muscle fatigue.

Players of black or aboriginal origin sustain significantly more hamstring strains than white players[23]. It has been suggested that these players may be faster runners compared to their white counterparts, possibly because of a higher proportion of type II muscle fibres. A faster running speed will generate higher hamstring torques, which may explain the increased injury risk.

METHODS TO PREVENT HAMSTRING STRAINS

There is now solid recent research showing that hamstring strains can be prevented, initially from observational studies and finally from a large-scale randomised clinical trial from Danish football.

Various studies have examined intervention methods targeting the key risk factors for hamstring strains: hamstrings strength, hamstrings flexibility and previous injury. In addition, one observational study on South African rugby players suggests that the use of thermal pants might reduce the risk of hamstrings injuries[24].

The consistent finding that a history of previous injury leads to a several-fold increase in the risk for new strains has of course lead to the suggestion that this is at least partly due to inadequate rehabilitation and early return to sport. A study from Swedish soccer[25] has documented that a coach-controlled rehabilitation programme consisting of information about risk factors for re-injury, rehabilitation principles and a 10-step progressive rehabilitation programme including return to play criteria reduced the re-injury risk by 75% for lower limb injuries in general. Although the specific effect on hamstring strains could not be assessed in this study, it seems reasonable to recommend including functional and specific rehabilitation programmes and careful screening of players before return to play.

Stretching

There are no intervention studies of elite athletes on the preventive effect of flexibility training on hamstring strains. However, one study on military basic trainees indicates a reduced number of lower limb overuse injuries after a period of hamstring stretching[26], while another military-based study found no effect of stretching[27]. However, it should be noted that these studies were designed to examine the effect of general stretching on lower limb injuries in general, not a specific hamstring programme on hamstring strain risk.

Questionnaire-based data on flexibility training methods collected from 30 English professional football clubs, where the stretching practices of the teams were correlated to their hamstrings strain rates, indicate that using a standard stretching protocol reduces injury risk[28]. Also, one study from Australian Rules football has observed a reduction in the incidence of hamstring strains with a three-component prevention programme, where stretching while fatigued was one of the components[29]. The

Figure 1: The Nordic hamstrings exercise. Subjects are instructed to let themselves fall forward and then resist the fall against the ground as long as possible by using their hamstrings. ©Oslo Sports Trauma Research Center.

other factors in the programme were sport-specific training drills and high-intensity anaerobic interval training. Thus, it is not possible to determine which of these factors are responsible for the observed effect. Also, the Norway-Iceland hamstring study did not show any effect of stretching, but it should be noted that teams were not randomised to the stretching programme[2].

Hamstring strength

The best evidence for injury prevention is available for programmes designed to increase hamstring strength, particularly eccentric hamstrings strength. Several studies indicate that low hamstring strength is a risk factor for sustaining hamstring strains[18,30,31]. EMG studies have shown that activity is highest late in the swing phase and during heel-strike, when the hamstrings work eccentrically or transfer from eccentric to concentric muscle action[16,32]. It is assumed that most hamstring strains occur during eccentric muscle actions, when the muscle activity is highest[33,34]. It is well-documented that strength training is mode specific[35–39]. Based on this it may be argued that, to be specific, strength training for the hamstring muscles should be eccentric.

It has been suggested that an indicator of susceptibility for the damage from eccentric exercise is the optimum angle for torque[40]. When this is at a short muscle length, the muscle is thought to be more prone to eccentric damage. By means of isokinetic dynamometry it has been shown that mean optimum angle in previously injured muscles is at a shorter length than for uninjured muscles.

Hamstring strength exercises

Recent studies from Scandinavia have shown that replacing the traditional hamstrings strength exercise used by teams – hamstring curls – with exercises to develop eccentric strength reduces the risk of hamstring strains[2,41]. Traditional hamstring curls have been shown to be ineffective in increasing eccentric hamstring strength among elite athletes[39]. In contrast, a simple partner exercise, the Nordic hamstring exercise (Figure 1), has been demonstrated to be effective in improving eccentric strength[39]. A pilot study has also shown that using a special apparatus, the YoYo flywheel ergometer, also increases eccentric hamstring strength[41]. Both of these methods have been shown to prevent hamstrings strains in studies on soccer players[2,41,42] and rugby players[8].

However, the best evidence for the preventive effect of eccentric strengthening of the hamstring muscles is a randomised controlled trial from Denmark comparing the effect of the Nordic hamstring exercise to no additional hamstring exercise on the rate of acute hamstring injuries in male soccer players[42]. This study on 942 male professional and amateur soccer players showed that injury rate was 71% lower in the Nordic hamstring exercise group (3.8 injuries per 100 player seasons vs 13.1). For players with a history of hamstring strains, the effect was even more pronounced, with 86% reduced rate in the Nordic hamstring group. In other words, there is convincing evidence of a substantial protective effect of this exercise programme.

Another reason to recommend Nordic hamstring lowers as a specific tool to prevent hamstring injuries is that the programme is easily implemented in a team setting. A controlled trial has also documented that if the recommended exercise prescription shown in Table 1 is followed, with a gradual increase in training load when introducing the programme of Nordic hamstring lowers, players experience no delayed onset muscle soreness. By the end of a 10-week training period, many players are able to stop the downward motion completely before touching the ground (i.e. at about 30° of knee flexion), even after being pushed by his or her partner(s) at a considerable speed. When a player can reach this stage, the characteristics of the Nordic hamstring lower exercise appear to resemble the typical injury situation: eccentric muscle action, high forces, near-full-knee extension. The programme has been implemented in several different sports and younger age groups and injuries from the exercise itself have not been recorded.

WEEK	SESIONS/WEEK	SETS	REPS	LOAD
1	*1*	*2*	*5*	*↑ load when athlete can control fall forward. When 12 reps can be achieved, ↑ load by: a) Adding speed to the starting phase of the motion. b) Having partner push back of the shoulders.*
2	*2*	*2*	*6*	
3	*3*	*3*	*6 - 8*	
4	*3*	*3*	*8 - 10*	
5 - 10	*3*	*3*	*12 - 10 - 8*	

Table 1: Training protocol for Nordic hamstring group[39]. Load is increased as subject can withstand the forward fall longer. When managing to withstand the whole range of motion for 12 reps, increase load by adding speed to the starting phase of the motion. The partner can also increase loading further by pushing at the back of shoulders.

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