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A ORGANIZED MOVE TOWARD HARMSTRING AVOIDANCE AND TREATMENT

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Abstract- Acute hamstring injuries are the most prevalent muscle injuries reported in sport. Despite a thorough and concentrated effort to prevent and rehabilitate hamstring injuries, injury occurrence and re-injury rates have not improved over the last three decades. This failure is most likely due to the following: (1) a lack of studies with high level of evidence into the identification and prevention of hamstring injuries and (2) a reductionist approach of the current literature. The objectives of this article are to review and critique the current literature regarding isolated risk factors, and introduce a new concept for a more comprehensive scientific understanding of how multiple risk factors contribute to hamstring strain injury. The authors hope that this new conceptual model can serve as a foundation for future evidence-based research and aid in the development of new prevention methods to decrease the high incidence of this type of injury.
Key words- injuries, isolated, occurrence, incidence, prevention, multiple

Introduction

Following hamstring strain, rehabilitation is often prolonged and frustrating for the athlete and for the sports medicine clinician. Though the initial treatment of rest, ice, compression and elevation is accepted for muscle strains, no consensus exists for rehabilitation of hamstring muscle strains. This lack of agreement concerning rehabilitation of hamstring injury represents our lack of understanding of the mechanism of injury and the factors that contribute to hamstring strain. A hamstring rehabilitation model is proposed that is based on our current understanding of the aetiological factors that contribute to hamstring muscle strain. The influence and interaction of hamstring strength, flexibility, warm-up and fatigue are aetiological factors that should be addressed in the rehabilitation and prevention of hamstring strains. The rehabilitation model is, however, not without limitations and speculations. Hamstring injuries are becoming more prevalent in many field sports around the world. The field sports most affected are Australian Rules, Soccer, Rugby League, Rugby Union and American Football. This is continuing to occur despite a plethora of hamstring strengthening exercises designed to prevent these injuries. As practitioners we suggest an eclectic approach and offer some practical coaching applications based on published research and our experience. The problem of hamstring injuries can appear quite complex, but in reality we must look at the causes from a different view point. When approached from a different perspective, a number of possible solutions to hamstring injuries become apparent. It is important to emphasise that there is no one solution.

It's terrible to see and even worse to experience: a serious hamstring tear. The Olympic athlete has trained for years to get to the standard where he can mix it with the world's best. He's competing in the heats of the 100 meters and he's going well, into the second round. Suddenly, at 60 meters his head is thrown back, he clutches the back of his leg, he stumbles, the other competitors hear him cry out and he ends up prostrate on the track. It's all gone, all that training, all that time, all that effort and commitment. He's torn a hamstring muscle big time and it will take weeks, perhaps months to recover.

Of course, hamstring tears or strains of much lesser consequence are a problem in all walks of life from weekend warriors to professional dancers to sedentary homebodies who just extend themselves a bit too much. I can't say why this group of muscles is so relatively delicate but it probably has something to do with the evolution of primates from all fours to standing and running upright on two legs.

I'll take a look at what's known about the causes of hamstring tears and what you can do to prevent hamstring injuries with strength training and other measures.

What Causes Hamstring Injury?

Surprisingly little is known for certain about the prevention, causes and best methods of rehabilitation of hamstring injuries. Poor quality studies and absence of randomized trials, which are the most valuable, don't help either. Firm conclusions are in a minority and theoretical approaches in the absence of strong experimental studies are the norm. Here is a sample of

the possible causes of hamstring injuries discussed in sports medicine:

- Less than ideal lower back and core muscle strength and mobility
- Hamstring muscle inflexibility
- Quadriceps inflexibility
- Ankle inflexibility
- Greater quadriceps versus hamstring strength
- Less than ideal running mechanics
- Age -- older equals more susceptible
- Previous hamstring, knee or pubis injury
- Inadequate warmup
- Fatigue

Problem

The high incidence of hamstring strains in field sports primarily to the biceps femoris muscle that occur 1) during the switch between late leg recovery and initial leg approach in the swing phase, and 2) the ground contact phase of running.

Reasons

Primary

- Poor timing-intermuscular coordination and eccentric strength in the short head of the biceps femoris muscle during the switch between late leg recovery and initial leg approach in the swing phase of sprinting [1].
- Lack of stiffness and eccentric strength in the short and long head of the biceps femoris muscle during the ground contact phase of running [2]. Stiffness refers to the ability of the muscle to absorb shock and rebound. Dropping a golf ball onto concrete is an example of stiffness; it immediately rebounds off the surface. The opposite would be would be sagging or a slight collapsing on contact.
- Previous strain — prior hamstring injury is a very good indicator of potential for future injury [3].

Secondary

- Poor running mechanics — this consists primarily of overstriding which puts the hamstrings in a vulnerable position at ground contact. Also excessive sway or lateral deviations that force the synergistic stabilising muscles to overwork subsequently shifting more stress to the hamstrings. The hamstrings do not work alone, they need help. Poor technique when running curves and angles will put more stress on the hamstrings because of the work they have to do in the transverse plane.
- Improper warm-up or lack of warm-up — there is often confusion between stretching and warm-up. Stretching is not warm-up; the warm-up must be active and dynamic to prepare the muscles for the forces involved. Stretching is only one segment of warm-up.
- Inappropriate training loads — high speed work placed inappropriately in the workout will predispose the athlete to hamstring pulls. The hamstrings are primarily fast twitch Type II fibres that fatigue quickly. This demands that high speed work be done early in workout, as close to warm-up as possible to avoid fatigue. Higher intensity speed endurance work must be gradually built into the program to allow for adaptation. This type of work must be built on a sound foundation of running mechanics.
- Fatigue (neural and local muscle) — because the hamstrings are primarily fast twitch Type II fibre, all activities that occur in the course of a game must be taken into consideration, for example, in AFL fatigue arising from running then sprinting and kicking.
- Lower back pathology — abnormalities of the lumbar spine that potentially could cause nerve dysfunction, which in turn lead to muscle weakness.
- Playing surfaces — a wet slippery surface will put more strain on the hamstring due to slipping.

Hamstring function

In order to select effective exercises to prevent hamstring injuries and optimise sprinting performance, it is necessary to understand hamstring function. The nature of the injury and the phase of the stride cycle where the injury commonly occurs provide a major indication of hamstring function as well as insights into the mechanism of injury. Despite this clear evidence of hamstring function and the biarticular nature of the hamstrings there is a continued search for ways to isolate the hamstrings in order to strengthen them. With the understanding of the eccentric role the hamstrings play in the stride cycle, some people (the authors included) searched for ways to strengthen the hamstrings eccentrically. Unfortunately, most of those methods still relied on single joint movements, for example:

- hamstring curl (regardless of the position of the body)
- ham/gluteal raise — this is an exercise that has gained much favour, but it still isolates the hamstring in a position of mechanical disadvantage
- Kneeling Russian hamstring exercise — executed from a kneeling position with a partner securing the ankles. Slowly lower, extending the knees. This puts undue stress on the distal hamstring. In the authors' experience this has caused many hamstring problems.

All of the above exercises certainly do work the hamstrings eccentrically, but the problem is that they all isolate the hamstrings by working at one joint, the knee. None of the exercises contribute to intermuscular coordination nor do they work the hamstrings at

anywhere near the speed necessary to transfer to performance. Furthermore, the Kneeling Russian Hamstring exercise in particular excessively loads the hamstring distally. All these exercises are contraindicated.

Location of injury

Injury data indicates that around 80 per cent of hamstring strains occur in the biceps femoris muscle [5]. There is some disagreement in the sports medicine literature whether hamstring strains occur at the switch between late leg recovery and initial leg approach in the swing phase of sprinting, or during the early to mid phase ground contact phase of sprinting. However, when consideration is given to EMG (electromyography) research, biceps femoris activity is at its highest just prior to and during the ground contact phase [4]. Furthermore, most of the hamstring strains that occur in the biceps femoris muscle occur in the long head of the muscle [5].

Criteria for prevention exercise selection

Hamstring injury prevention and performance enhancement exercises should be multiple joint, closed kinetic chain and eccentric in nature. The emphasis should be on exercises that enhance intermuscular coordination. The training of timing and coordination is essential. Timing and coordination has not received much emphasis because it is difficult to measure. Timing and coordination demand a clear understanding of sprint mechanics and the adaptation of those mechanics to multidirectional field sports where the incidence of hamstring injuries is so high. It is imperative to examine the plethora of 'sprint type' exercises in order to determine their transfer to the skill of sprinting. The goal should not be more drills, but finding drills that work. The drill must not be an end unto itself; it should contribute to coordinating the hamstrings in patterns that transfer to the demands of the activity. Also, in order to withstand the large eccentric load that must be attenuated during ground contact, exercises that train muscular stiffness and reactivity need to be included as part of a comprehensive injury prevention and performance enhancement program.

Another prevalent thought in sports medicine circles is that hamstring injuries are due to a lack of stretching, or improper stretching in warm-up. There is nothing in the literature to support this belief. In fact, recent research has shown that static stretching in warm-ups plays little or no role in injury prevention. This area warrants further research to refute or verify what the practitioners have experienced. There is no doubt that the lack of an active and dynamic warm-up is a contributing factor to many hamstring muscle strains.

Continuum of injury prevention/performance enhancement exercise

The placement of exercises on the continuum is ultimately determined by the relationship to the function of the hamstring in actual running. It helps to look at the continuum as progressing from a low-speed,high-force to high-speed high-force exercises that are ballistic in nature. At the general end of the continuum the exercises do not as closely resemble the criteria activity. As the exercises progress along the continuum the movement pattern is similar and force time characteristics more closely resemble the actual activity. The goal of all of these is multifaceted: to improve functional strength, improve intermuscular coordination and improve mechanics of sprinting.

Complementary exercies

The following training modules contain complementary exercises that should be implicit in a comprehensive strength and conditioning program.

General

- Double leg Romanian dead lifts
- Single leg Romanian dead lifts
- Low step-ups - posterior resistance
- Lunge and reach – three planes
- Walking lunge into high knee

Special

- Hanging horizontal bridge
- Cable hip extension
- Resisted moonwalks

Specific

- Straight leg bounds
- B drills
- 15-degree hill sprints

Although they may not specifically train the hamstrings, they involve them in patterns of movement that force them to work through amplitudes of movement and at speeds that prepare the hamstrings for the stresses they will encounter in sprinting and multi-directional movement.

- Running technique training – this should be fairly obvious, but the necessary attention to detail and the time required to carry this out puts coaches off. This does not entail making the athlete conscious of hamstring firing or involvement, rather the emphasis is on the rhythm and flow of the movement. Posture and relaxation are primary considerations. This should involve work at top speed, starting at ten metres and working up to alternating periods of hitting top speed and floating at top speed. It is also imperative to work on the mechanics of running involving curves and angles to condition the body for the differing demands that put the hamstrings at risk. Stair running is a good means to reinforce correct top speed mechanics without undo stress on the hamstrings. The stair sprints should not exceed ten seconds in duration. The emphasis is on 'hips over the foot' at contact and tall posture.
- Mach sprint drill series - this series was designed by Gerard Mach as exercises to develop specific strength in the muscles used in sprinting. There is some carryover to technique but they are primarily specific

strengthening exercises. The B series of foreleg extension and pawing back has little relationship to technique, but it is a primary exercise to strengthen the hamstrings as they work to decelerate the foreleg. The skipping aspect of the drills serves to train the stiffness component to learn to optimise ground contact. When executing the skips it is imperative to actively drive the foot into the ground to set up the proper ground reaction.

- Low amplitude hops/jumps – these serve to facilitate muscle stiffness. Stiffness is the opposite of sagging which would be the leg collapsing at ground contact. This aspect has not received as much emphasis as its role in sprinting demands. Straight leg bounds, ankle bounces, low hurdle hops all reinforce stiffness. The emphasis here should be on the knee being almost locked. Emphasise bouncing type movements which result in very short ground contact times. Cue the athlete that the ground is hot.
- Hurdle dynamic hip mobility exercises – hip mobility or a lack thereof that is the genesis of many hamstring problems. These drills should be incorporated daily as part of warm-up or cool down. Without proper hip mobility the leg will not be able to work through the full range of motion. This limitation will eventually lead to flawed mechanics especially in a fatigued state. These exercises, both walking over and under the hurdles should be part of the athlete's daily routine of warm-up or cool down.
- Resisted hip abduction/adduction exercise – the hip abductors and adductors play a major role in stabilisation. In fact the adductor magnus is sometimes referred to as the fourth hamstring. If they are weak or not coordinated with the hamstrings more strain will be placed on the hamstrings. This can be structured as part of daily warm-up utilising a series of exercises with a small rubber band placed above the ankles.
- Fifteen-degree hill sprinting – hill sprinting at a 15-degree grade provides an excellent means to develop good top speed mechanics. It is virtually impossible to overstride sprinting up hill.

Contraindicated exercises

Based on Lieber's (2002) work on muscle architecture and what we know of muscle function from biomechanical studies there are certain exercises that are contraindicated. They are:

- hamstring curl - regardless of the position of the body [2]
- Roman chair hamstring/gluteal raise
- kneeling Russian hamstring exercise
- Swiss ball bridging exercises.

These exercises are contraindicated because of the non functional position of the body and the fact that they all work the hamstrings at one joint. These exercises are often used because you can 'feel the burn' during execution. That is a poor reason to choose an exercise. The burn is felt because the hamstring is at a mechanical disadvantage.

Contraindicated training modalities

- Treadmill sprinting – treadmill sprinting and overground sprinting are different activities. The treadmill allows the athlete to place the foot farther in front of the centre of gravity than would be possible in overground running because the ground is not moving under the athlete, the athlete is moving over the ground. Empirical evidence based on the authors' experience is that athletes who make extensive use of treadmill training are more prone to hamstring strains.
- Overspeed sprinting with elastic tubing - this method, regardless of the modality, is trying to get the athlete to run faster than they are capable of running of their own volition. There is a tendency, especially with the elastic cord, to 'reach' and 'break' to alleviate the fear of falling. This obviously reinforces overstriding which predisposes the athlete to hamstring pulls.

Fallacious training modalities

- Backward sprinting (running) – this has assumed almost mythological status as a hamstring strengthening and preventive exercise. EMG studies have shown that during backward running the hamstrings are essentially silent; they are along for the ride. Backward running works the quadriceps, most specifically the VMO and the gastro/soleus complex. So it is not a waste of time, but it doesn't help the hamstrings directly. The work on the gastroc/soleus may help train that group to be stiffer at ground contact which contributes indirectly to helping the hamstrings.
- Butt kicks – this is a classic misunderstanding of the difference between similar and same. It appears to mimic what happens in the stride cycle, but in reality the legs flex as a result of ground reaction forces and momentum, the hamstrings contribute minimally immediately after toe off in the running stride [4]. Remember that the hamstrings' primary job is not to flex the knee. The butt kick is telling the hamstring to flex the knee, in essence creating neural confusion. It is not an exercise worth spending much time on.

Conclusion

There is much misunderstanding on the role of the hamstrings in the coaching and the medical community.

In the world of elite sprinting, given the explosive ballistic high-speed and high-force nature of competition and training, the hamstrings are particularly at risk. Prevention and rehabilitation of hamstring injuries should be part of a systematic approach to training. This should encompass daily exercises to enhance speed and agility as well as remedial exercises to address any individual deficiency of the athlete.

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