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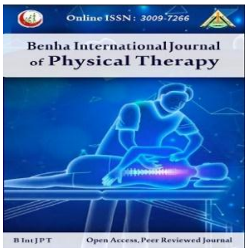

Review research

Acute hamstring muscle strains and the physiotherapy role: a narrative review

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Abstract

Background: The most common muscle strain is an acute hamstring strain, which has a high recurrence rate and the potential for prolonged absence (>28 days) from sports. The goals of hamstring injury rehabilitation are to achieve the pre-injury level of functional activity and to return to sports with minimal risk of recurrence. **Purpose:** The purpose of this study was to review the literature about acute hamstring muscle strains and their physical therapy interventions. **Methods:** The published studies in the PubMed, Google Scholar, SciELO, LILACS, and Cochrane Library databases that studied hamstring strains were reviewed. Studies of high to fair quality, like systematic reviews, meta-analyses, and RCTs, were included. Studies of low quality and studies that didn't match the scope of the current study were excluded. **Results:** Neuromuscular control, core stability, and eccentric strength exercises have reduced both the time needed to return to sport and the risk of hamstring re-injury. The recommended rehabilitation protocol is divided into three stages with specific treatment goals and progression criteria. Other physical therapy modalities, like US, cooling, and massage, are widely used, but their effectiveness is arguable. The return to sport decision-making is widely debated. **Conclusion:** The amount of time needed for rehabilitation depends on the location and severity of the injury. Besides the recommended rehabilitation protocol, neuromuscular control, core stability, and eccentric strength exercises are effective rehabilitative and preventive programs. A gradual return to full sporting activity demands and continued independent rehabilitation are critical for lowering the risk of re-injury.

Keywords: Hamstring strain, Physical Therapy, Rehabilitation, Exercises

Introduction

Acute hamstring strains are the most common muscle strain among professional athletes[1]. It was reported to be 14.8% and 12% of all injuries in Egyptian football and British soccer, respectively[2,3]. It has a high recurrence rate, which was reported to be 27% in the Australian Football League[4]. In addition, it's responsible for impairment, activity limitation, and prolonged absences (>28 days) from training and playing soccer[5,6].

The goals of its rehabilitation programs are to restore functional activity to pre-injury levels and to

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help athletes to return to sports with the lowest risk of recurrence. Therefore, minimizing the risk of re-injury and enhancing athlete performance require identifying the kind of rehabilitation program that best supports muscle tissue and functional recovery[7]. Many physical therapy modalities are widely used to achieve complete recovery, but their efficacy hasn't been fully established yet[8,9].

The purpose of the current study was to review the role of physical therapy in acute hamstring muscle strains. The published studies in the PubMed, Google Scholar, SciELO, LILACS, and the Cochrane Library databases, which studied hamstring strains, were reviewed, using the following keywords: hamstring strain, hamstrings injury, muscle injury, muscle strain, physical therapy, rehabilitation, and therapeutic exercises. Studies of high to fair quality, like systematic reviews, meta-analyses, and randomized controlled trials (RCT), were included. Studies of low quality and studies that didn't match the scope of the current study were excluded.

Injury classification

Acute hamstring strain injuries can be classified according to either the severity[10,11] or the mechanism of injury[1,12]. Regarding the severity, **Grade I** describes a minimal tear or loss in the integrity of the muscular structure. It's associated with mild inflammation and no loss of strength or function**. Grade II** describes a partial or incomplete tear or loss in the integrity of the muscular structure. It's associated with a muscular edema, a localized hematoma, and a moderate loss of strength or function. **Grade III** describes a complete tear or loss in the integrity of the muscular structure. It's associated with a complete loss of strength or function[10,11]**.**

Regarding the mechanism of injury, **over eccentric contraction** occurs during high speed running when decelerating the swinging limb and preparing for foot strike. The most commonly involved muscle is the long head of the biceps femoris, particularly the musculotendinous junction. Commonly, it's a fast recovery strain. **Massive stretching** occurs due to excessive lengthening in the hamstrings when hip flexion is combined with knee extension. The most commonly involved muscle is the semimembranosus muscle, particularly the proximal free tendon close to the ischial tuberosity. Commonly, it's a prolonged recovery strain[1,12].

Healing process

Muscle healing is distinguished by a reparative process that results in the formation of a scar. There are three stages of skeletal muscle healing. **Stage 1** is the destruction phase (3-7 days), which is distinguished by myofibril disruption and necrosis, hematoma formation, and the initiation of the inflammatory response. **Stage 2** is the repair phase (4-21 days), which is distinguished by necrotic tissue phagocytosis, myofibrils regeneration, scar tissue production, and vascular neo-formation. **Stage 3** is the remodeling phase (2-14 weeks). This is the time when the regenerated myofibrils organize and mature and the muscle's functional ability is restored[13,14]**.**

Risk factors

There are two categories of risk factors for acute hamstring strain: modifiable and non-modifiable[15]. In terms of modifiable ones, **the kind of sport** played could have an impact on the likelihood of acute hamstring strains. Sports involving prolonged muscle lengthening exercises, such as football, and overly eccentric activities, such as dance, are more likely to cause hamstring strains. **Muscle imbalance**, like the strength ratio of the concentric quadriceps and eccentric hamstrings of the same limb and the bilateral relationship of the hamstrings, is associated with a 4-fold increase in the incidence of hamstring strains. **Muscle fatigue** is considered a risk factor. When muscles are highly fatigued, such as during the final stages of competitive training or matches, hamstring injuries are more common. **Hamstring flexibility deficit** has been identified as a risk factor; however, this is not universally acknowledged, as additional study has shown that a lack of flexibility is not linked to injury[16-19,20]**.**

In terms of non-modifiable risk factors**,** the most significant risk factor for hamstring injury has been determined to be **past hamstring injury**. One independent risk factor that has been found for Australian soccer and football players is **aging**. Given that athletes of Aboriginal, Black African, or Caribbean descent are more likely to have hamstring strains, **race** may be regarded as a risk factor. According to reports, there is a correlation between **gender** and risk of acute hamstring strain in sports, with male athletes having a 64% higher chance than female players[21-25].

Diagnosis

For diagnosing a suspected hamstring strain, a history and physical examination are required. The referred pain to the posterior thigh from the lumbar spine, sacroiliac joint, and hip joint is an appropriate differential diagnosis due to the overlapping pain patterns[26]**.** The following symptoms are seen in the acute phase of most hamstring injuries: a sudden onset of posterior thigh soreness or at the ischial tuberosity caused by a specific activity, an audible pop with the onset of pain, and a previous hamstring injury that is frequently adjacent to or near the site of the current injury[8]**.**

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Visible ecchymosis along the posterior thigh and knee and distal to the injury is a sign of grade II or III (moderate to severe) hamstring strains[10]. Pain provocation while palpating the posterior thigh determines the injured region. A defect in the musculotendinous unit can be determined by palpation. It is important to pay particular attention to the hamstring origin at the ischial tuberosity since the longer it takes to resume pre-injury activity levels, the closer the site of greatest discomfort is to the lesion[1,12,27,28]. Furthermore, neural tension tests, like the slump test can be used to rule out lumbar spine or sciatic nerve involvement[8].

Manual resistance at the knee and hip is recommended for assessing hamstring strength. For example, when the hip is stabilized, isometric strength and pain provocation should be assessed at 0°, 15°, and 45° of knee flexion. Each measure should be subjected to a bilateral comparison[8,29]. Both the hip and knee joints should be assessed for flexibility by both passive straight-leg raising for the hip and active knee extension for the knee. A bilateral comparison is advised once more[8,30].

Imaging is usually not required to diagnose an acute hamstring strain. When an ischial avulsion injury is suspected, an x-ray could be used. In order to accurately identify and assess the extent of acute hamstring strain injuries, ultrasound (US) and magnetic resonance imaging (MRI) are performed. However, for assessing the deeper muscles, MRI has been shown to be more accurate than US[31].

Treatment

The goals of the rehabilitation are to restore functional activity to pre-injury levels and to allow athletes to return to sports with minimal risk of recurrence. The time needed for rehabilitation depends on the location and severity of the injury[28]. Injury to the origin tendon (proximity to the ischial tuberosity) and increased volume of the edema (cross sectional area and longitudinal length) all necessitate a longer time to return to sport[1,27,28,31].

There is no clear evidence that medications (NSAIDs)[31] or platelet-rich plasma (PRP) have any effect on the time required to return to sport or the recurrence rate although it increased the concentration of platelets in an injured area which could promote healing[32]. On the other hand, use of NSAIDs is not recommended because of their inhibitory effect on satellite cells, macrophages, and protein formation[33]. Many physical therapy modalities are widely used to achieve complete recovery[8], but their efficacy hasn't been fully established yet due to the sparse scientific research on the subject[9].

Therapeutic modalities

Immediately after the injury, the protection, rest, ice, compression, and elevation (PRICE) protocol is the traditional treatment for acute muscle injuries to reduce the perfusion, inflammatory signs, and metabolic rate. The primary goal is to limit the total amount of injured tissue by enhancing the ability of muscular tissue to survive secondary injury events[34,35]. Thus, cryotherapy has been recommended for 10 min every 2 hours[36].

Therapeutic US is a popular treatment option for musculoskeletal injuries. Its acoustic vibration results in cellular changes, which may increase protein synthesis and proliferation of the fibroblast and stimulate angiogenesis[37]. However, the effectiveness of therapeutic US in the muscle injury repair process is arguable[9].

Low level laser therapy (LLLT) is a light source that penetrates the tissue well. The LLLT stimulates the production of adenosine triphosphate (ATP), improves satellite cell and fibroblast migration, and enhances angiogenesis. These effects could help to improve muscle regeneration and prevent tissue fibrosis[38,39].

Manual therapy

Hand contact results in an analgesic response and improved muscle and joint function by stimulating mechanoreceptors. Mechanoreceptor stimulation causes afferent impulses, which result in neuromodulations in the central nervous system. Various types of massage, like Swedish massage, deep friction massage, trigger point massage, and shiatsu massage, could be used for improving circulation, decreasing muscle spasm, promoting relaxation, realigning soft tissue, breaking adhesions, and increasing ROM[40].

Sacroiliac joint (SIJ) manipulation could be beneficial for individuals with hamstring strains based on the proposed link between hamstring strains and pelvic hypomobility[41].

Hamstring strains, particularly grade III, could cause a mobility deficit in the sciatic nerve due to scar tissue formation. Neural mobilization enhances nerve conduction and intrinsic mobility while decreasing mechanical sensitivity. Neural mobilization for the sciatic nerve has been advised as a component of the rehabilitation program in case of a positive active slump test during the examination[42].

Therapeutic exercises:

Neuromuscular control exercises, stabilization training, and eccentric strength training have been reported to effectively reduce both the time needed to return to sport and the risk of hamstring re-injury. They have been recommended for the rehabilitation program of hamstring strains[30,43-47].

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Neuromuscular Exercises

Neuromuscular training programs that include a variety of exercises, like balance, strength, stretching, running, cutting, agility, plyometrics, and landing technique, can decrease the risk and severity of lower limb injuries, particularly hamstring strains[44,45]. Proprioception-based programs have been reported to be effective in both injury prevention and muscle injury treatment. Sports-specific proprioceptive exercises with increasing complexity and challenge (from linear and low demand exercises to multidirectional and explosive exercises) are ideal[45-48].

Stabilization training

Because the contralateral hip flexors (iliopsoas) have as much influence on hamstring stretch as the hamstrings themselves, lumbo-pelvic muscles could affect the function of the hamstring during running by producing a pelvic tilt[49,50]. Core stability exercises help athletes achieve and maintain a neutral spine position during athletic performance[51]. Following a hamstring strain, a progressive trunk stabilization and agility program significantly decreased both the time required to return to sport and the re-injury rate compared to a progressive stretching and strengthening program[30]. Furthermore, it was as effective as the progressive running and eccentric strengthening program regarding the time required to return to sports. However, re-injury rates were lower in the progressive agility and trunk stabilization program[47].

Strengthening (Eccentric)

After eccentric training, the peak torque angle shifts to longer muscle length, and the shift is greater when more hamstring muscle elongation is achieved during loading. This shift in peak force development may help to restore optimal musculotendinous length. Concentric exercises could produce that shift in hamstring peak torque angle only if they were performed at longer lengths[52,53]. Starting with isometric and then concentric exercises is critical for regaining bulk and strength while supporting tissue healing[48]. Eccentric loading can be done at lower angular velocities because it protects against the very high angular velocities during running[52].

Program emphasizing eccentric exercises significantly decreased the time required to return to sport compared to a program emphasizing less eccentric exercises in individuals with hamstring strain[28,54]. Also, combining the controlled eccentric exercises with the rehabilitation program could decrease the rate of hamstring re-injury[53].

Stretching Exercises

Reduced hamstring flexibility may be a risk factor for hamstring strains and has been used to grade the severity of hamstring injuries. Positive results have been reported for hamstring strain rehabilitation based on either stretching exercises[55] or increasing ROM[41]. However, there is no agreement on whether stretching decreases the risk of injury or enhances performance[56].

Guidelines for designing the exercises

In addition to exercise parameters, like contraction type and load, ROM, uni- or bi-lateral, and open or closed kinetic chains, it's critical to consider hamstring anatomy and function, injury mechanism, and type of sport when designing the exercises[52]. Therefore, exercises should be individualized based on a person's ability and goals. In order to, and progressively progressed until rehabilitation exercises mimicked sport movements and load demands[46].

The concept of "elongation stress on hamstrings" (ESH) was recently used to describe the assessment of hamstring elongation during exercise and function. This is estimated by subtracting the flexion angle of the knee from the flexion angle of the hip[57]. Higher hamstring tissue stress is associated with greater positive ESH values[52]. Therefore, performing strength exercises with a long musculotendinous length and a high hip angle may be more beneficial for preventing injuries due to the shift in peak torque angle with longer muscle length[57].

Rehabilitation protocol:

The recommended rehabilitation protocol, summarized in **Table 1,** consists of three stages, each with its own set of treatment goals and criteria for stage advancement and return to sport. A potential complication of this rehabilitation protocol is symptom intensification due to exercise intensity and ROM. Therefore, the suggested exercises, including sets, repetitions, and progression, should be tailored to the athlete, with progression being limited if the athlete reports pain, stiffness, or anxiety with movement **(Fig. 1, 2).** The progression through the three stages should be individualized based on the criteria for stage advancement[7,8].

Figure 1: Single-limb windmill touches with dumbbells: begin in [A] single-limb stance position and [B] perform windmill motion under control with end position of touching dumbbell near floor.

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Table 1: Rehabilitation protocol for acute hamstrings strain[6,8].

	Phase 1: Acute phase [0-4 weeks]	Phase 2 Sub-acute phase [2-8 weeks]	Phase 3 Functional phase [4-8 weeks and beyond]
Goals	• Protect scar development • Minimize atrophy	• Regain pain-free hamstring strength, beginning in mid-range and progressing to a longer hamstring length • Develop neuromuscular control of trunk and pelvis with progressive increase in movement speed	• Symptom-free [eg, pain and tightness] during all activities • Normal concentric and eccentric hamstring strength through full range of motion and speeds • Improve neuromuscular control of trunk and pelvis • Integrate postural control into sport-specific movements
Protection	• Avoid direct stretching of the hamstrings • Shorten stride length to ambulate pain free • Use crutches if necessary	• Avoid end range lengthening if weakness persists	• Avoid full intensity if pain or stiffness persists
Pain and swelling control	• Cryotherapy/ice 2-3 times/d • Compression thigh wraps and elevation above heart • Activity modification to reduce tension	• Cryotherapy/ice Post exercise, 10-15 min, as needed	• Cryotherapy/ice Post exercise, 10-15 min, as needed
Manual therapy techniques	NA	• Normalize ankle dorsiflexion ROM [calf stretching] • Addressing spinal mobility limitations • Addressing pelvic and sacroiliac joint restrictions • Manual, instrumented, or self-directed soft tissue mobilization to limit excessive scar tissue formation • Neuromobilization techniques if the athlete displays adverse limb tension.	• Address remaining limitations in ankle, spinal, or pelvic mobility • More aggressive manual, instrumented, or self-directed soft tissue mobilization to limit excessive scar tissue formation • Neuro mobilization techniques if the athlete displays adverse limb tension
Therapeutic exercises	[daily] • Stationary biking for easy motion x 10 min • Progressive agility and trunk stabilization ○ Side stepping, low-to-moderate-intensity, x10 m, 3 x1 min. ○ Grapevine stepping, low-to-moderate-intensity, x10 m, 3 x1 min. ○ Single-leg stance, eyes open and eyes closed, 4 x20 s ○ Prone abdominal bridge, 5 x10 s ○ Supine bridge, 5 x10 s ○ Side bridge, performed on each side, 5 x10 s	• Stationary bike x10 min • **Progressive agility and trunk stabilization** ○ Side - shuffle, Moderate-to-high-intensity, pain-free speed and stride, x10 m, 3 x1 min. ○ Grapevine stepping, Moderate-to-high-intensity, pain-free speed and stride, x10 m, 3 x1 min. ○ Boxer shuffle, low to moderate intensity, pain-free speed and stride, x10 m, 2 x1 min. ○ Single-leg windmill touches ○ Supine extension bridge walk outs, , 5-s hold each side, 2 x10 reps ○ Push-up stabilization with trunk rotation, 5-s hold each side, 2 x10 reps ○ Side plank stabilization with trunk rotation, 5-s hold each side, 2 x10 reps ○ High-to-low and low-to-high wood chops ○ Single-limb balance windmill touches without weight, 4 x8 reps per arm each limb ○ Lunge walk with trunk rotation, opposite hand-toe touch and T-lift, 2 x10 steps per limb ○ Progressive balance training [balance board/unstable surface], 5 x10 s • **Eccentric resistance training** ○ Supine extension bridge bilateral heel slides, 3 x10 reps ○ Modified single-leg chair bridge, 3 x10 reps ○ The Diver, moderate-intensity, x10 m, 3 x1 min • The Glider, moderate-intensity, x10 m, 3 x1 min	• Stationary bike x10 min • **Progressive agility and trunk stabilization** ○ Side shuffle, moderate to high intensity, pain-free speed and stride, x30 m, 3 x1 min ○ Grapevine jog, moderate to high intensity, pain-free speed and stride, x30 m, 3 x1 min. ○ Boxer shuffle, moderate to high intensity, pain-free speed and stride, x10 m, 2 x1 min. ○ A and B skips, starting at low knee height and progressively increasing, pain-free ○ Forward and backward accelerations, 3 x1 min; start at 5 m, progress to 10 m, then 20 m ○ Single-limb windmill touches with dumbbells, 4 x8 reps per arm each leg **[Fig. 1]** ○ Lunge walk with trunk rotation and opposite hand dumbbell toe touch, 2 x10 steps per limb ○ T-lift lunge walk, 2 x10 steps per limb ○ Single-limb dead lift, 4 x8 reps per limb ○ Single-limb dumbbell hang clean, 4 x8 reps per limb ○ Repetitive hop for distance • **Eccentric resistance training** ○ Single-leg chair bridge, 4 x15 reps, slow to fast speed ○ Modified Nordic curls with resistance cables, , 4 x15 reps, slowly **[Fig. 2]** ○ Forward and backward running with anterior directed resistance band at waist, 3 x1 min; start at 5 m, progress to 10 m, then 20 m ○ Forward and backward fast feet with anterior directed resistance band at ankles, 3 x1 min; start at 5 m, progress to 10 m, then 20 m • Emphasize agility involving quick direction changes • Sport-specific drills that incorporate postural control and progressive speed
Criteria for progression to the next phase	• Normal walking stride without pain • Very low-speed jogging without pain • Pain-free isometric contraction against submaximal [50%-70%] resistance during prone knee flexion [90°]	• Pain-free isometric contraction against full resistance during prone knee flexion [45°] manual muscle test • Forward and backward jogging at 50%-70% speed without pain	NA

Abbreviations: d, day; min, minute; m, meter, rps, repetitions; s, second

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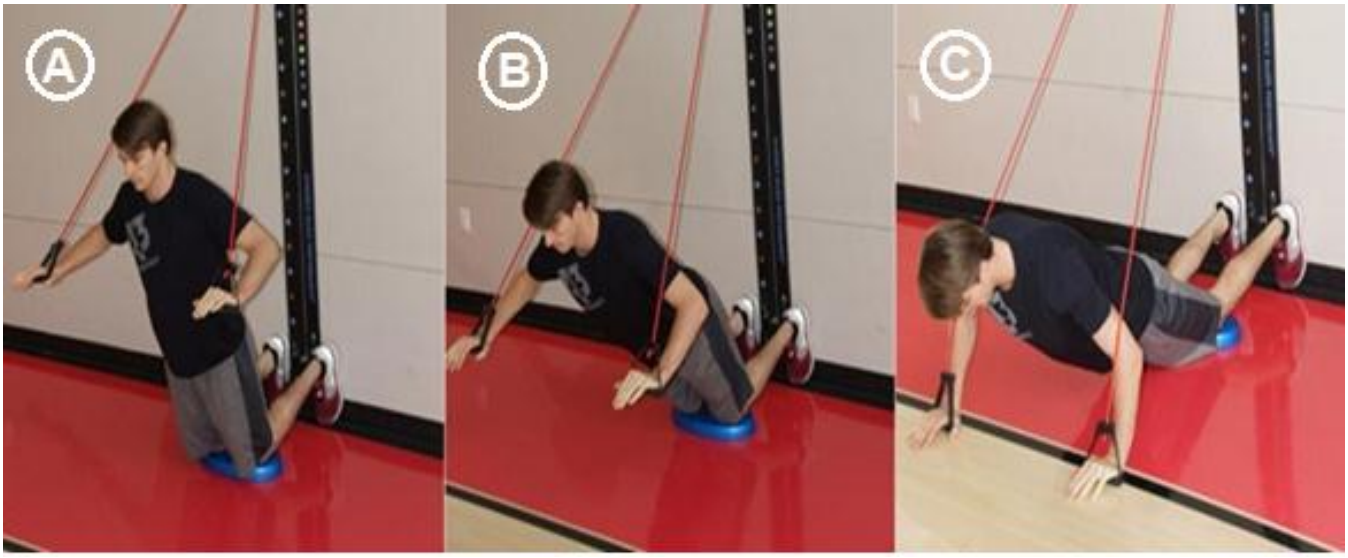

Figure 2: Modified nordic curls with assistance: begin in [A] tall kneeling, [B] slowly and under control lower trunk forward without flexing at the hip or arching the low back until [C] maximum motion occurs; return to starting position using push from floor and resistance cables to assist.

Criteria to return to sport:

Return to sport decision-making is widely arguable within the literature due to the lack of standardization and clear objective criteria. Erickson and colleagues [7] proposed an algorithm to help clinicians make decisions when permitting an athlete to return to sport **(Fig. 3)**[7].

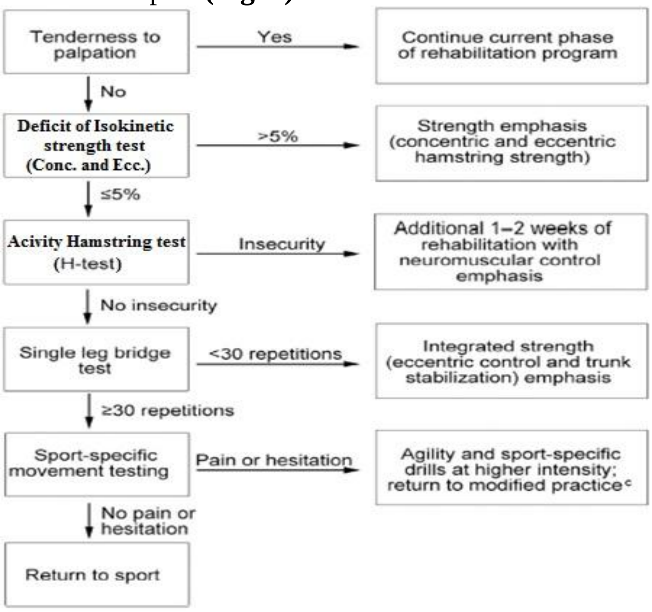

Figure 3: Algorithm for return to sport[7]**.**

Among professional soccer teams' sports medicine clinicians, complete pain relief was the most frequently used criterion for return to sport. Muscle strength was the second most common criterion. Isokinetic strength testing should be done under both concentric and eccentric conditions, at 60°/s and 180°/s, with a less than 5% deficit compared to the uninjured limb[58]. The active hamstring test (H-test) has been reported to be valid and reliable for detecting hamstring deficits in athletes prior to their return to sport[59].

Functional testing, like the single leg hamstring bridge, may predict the athlete's capability to return to sport if the athlete achieves a score of 30 repetitions or higher[60]. Also, sport-specific movements performed at near-maximal intensity and speed without pain, hesitation, or limitation may predict the capability of the athlete to return to sport[8,58]. Gradual return to full sporting activity demands, as well as continued independent rehabilitation following return to sport, are critical for lowering the risk of re-injury[7].

Injury Prevention Strategies

Prevention strategies that target specific risk factors, such as hamstring flexibility and strength deficits, have been proposed. Their effectiveness in reducing the incidence of hamstring strains is limited to a few studies[8]. Despite the fact that hamstring stretching is widely recommended for injury prevention, it hasn't reduced the incidence of hamstring strain injuries[46,61]. On the other hand, the use of eccentric hamstring exercises in daily routine, preseason, and in-season training has been reported to decrease the incidence of hamstring strain[43,46,62]. Neuromuscular control exercises for the lumbo-pelvic region and lower extremities have been reported to reduce hamstring injury incidence by 70% on average[44,63].

Conflict of interest

The authors declare that they have no competing interests.

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