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Current Exercise Approaches in Hamstring Strain Injury Rehabilitation in Athletes – Review

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Abstract

A hamstring strain injury (HSI) is common in sports that involve sprinting. This injury, categorized into strain-type and sprain-type, theoretically involves the hamstring muscle-tendon unit being exposed to high force, stretching beyond its normal limits, and moving at high speed. These three factors may lead to injury, either separately or together (although not yet fully understood). This review discusses current rehabilitation approaches based on studies conducted in the last 10 years. According to the literature, an HSI rehabilitation program for athletes should include a progressive running program, Askling L protocol eccentric exercises in the early phase, and high-load exercises such as Nordic exercises in later stages. Additionally, agility training and core stabilization exercises, which significantly help prevent re-injury, are considered as essential as eccentric exercises and should be included in the program. Although evidence on flexibility exercises remains insufficient, their inclusion in the rehabilitation program is deemed harmless. For all the mentioned exercise interventions—except for flexibility—there is conclusive evidence in the literature regarding their effectiveness in reducing the risk of re-injury and improving return-to-sport timelines for athletes.

Keywords: Hamstring strain injury, Askling-L, Exercise, Risk of re-injury, Return to sport

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Introduction

Hamstring strain injury (HSI) is a common type of lesion in sports involving high-speed activities. The literature divides strain injuries into two categories: strain-type and sprain-type, which can result from underlying repetitive microtrauma or macrotrauma (Danielsson et al., 2020; Hickey, Opar, Weiss, & Heiderscheit, 2022). This review aims to present the current exercise approach in the rehabilitation process of HSI based on recent literature.

Mechanism of Injury

Recent research suggests that HSI involves underlying repetitive microtraumas or macrotrauma (Danielsson et al., 2020; Hickey et al., 2022). However, the occurrence of an injury may result from the separate or combined influence of these three factors (still unknown): 1. High force in the muscle-tendon unit (active or passive). 2. Elongation of the muscle-tendon unit beyond its mid-length. 3. High-speed movement (Hickey et al., 2022). (Danielsson et al., 2020) reported in their study, that stretch-type injuries most often occur due to excessive hip flexion during knee extension. In contrast, sprint-type injuries are caused by eccentric contraction during the late swing phase of the running cycle. Danielsson also describes a third type of injury: a strength-related type. In this type, fatigue-induced reductions in eccentric force and endurance are typically observed, which increases the risk of injury.

Exercise Intervention

Progressive Running

Returning to running activities safely is an essential part of rehabilitation for athletes. In the literature, the most important progressive running protocol is the 12-stage 'progressive running schedule' presented in a study by (Silder et al., 2013) shown in Figure 1. However, in a randomized controlled trial (RCT) comparing pain-free rehabilitation with rehabilitation at the pain threshold, Hickey reduced the protocol to 9 stages (Hickey et al., 2020), and later, incorporating their clinical experience, proposed a more practical protocol consisting of 3 stages in a review they published (Hickey et al., 2022). The explanation of the protocol can be found in Figure 2.

PROGRESSIVE RUNNING SCHEDULE

Exercises

- 5 min of gentle stretching before and after each session, 3 × 20 s each
  - Standing calf stretch
  - Standing quadriceps stretch
  - Half kneeling hip flexor stretch
  - Groin or adductor stretch
  - Standing hamstring stretch
- Repeat each level 3 times, progressing to the next level when pain free
- Maximum of 3 levels per session
- On the following session, start at the second-highest level completed
- Ice after each session, 20 min

	Acceleration Distance, m	Constant Speed (Maximum, 75% Speed) Distance, m	Deceleration Distance, m
Level 1	40	20	40
Level 2	35	20	35
Level 3	25	20	25
Level 4	20	20	20
Level 5	15	20	15
Level 6	10	20	10
	Acceleration Distance, m	**Constant Speed (Maximum, 95% Speed) Distance, m**	**Deceleration Distance, m**
Level 7	40	20	40
Level 8	35	20	35
Level 9	25	20	25
Level 10	20	20	20
Level 11	15	20	15
Level 12	10	20	10

Figure 1. The progressive running protocol proposed by (Silder et al., 2013).

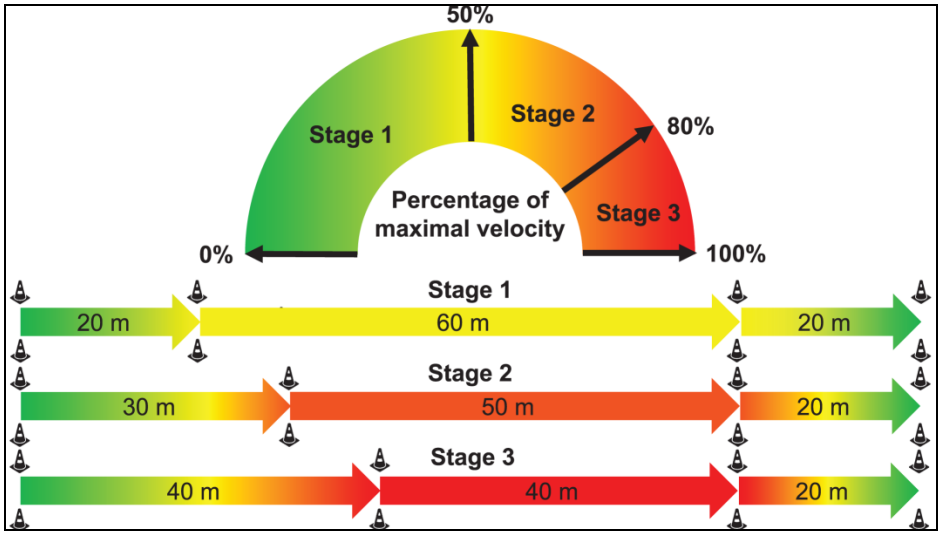

Figure 2. The 3-stage running protocol proposed by (Hickey et al., 2022). Stage 1: initiated when athletes can walk with minimal pain. In this stage, progression is made as the athlete tolerates running at 25% to 50% of maximum speed (moderate-speed running). Stage 2: This stage is started once moderate-speed running is tolerated. However, to minimize the risk of HSI, progression to Stage 3 should only occur when high-speed running (approximately 80% of maximum speed) can be performed pain-free. Stage 3: The goal in this stage is to reach 100% of maximum speed. Small increments (around 5%) should be made with careful attention to the eccentric workload of the hamstring muscle.

Eccentric Exercises

Eccentric exercises like the one shown in Figure 3 are known to play a role in reducing the risk of hamstring re-injury (Cuthbert et al., 2020; Hickey et al., 2022; Hickey et al., 2020; Nicholas J Ripley, Cuthbert, Comfort, & McMahon, 2023; Nicholas Joel Ripley, Cuthbert, Ross, Comfort, & McMahon, 2021; Silder et al., 2013; Vermeulen et al., 2022). In their systematic review, (Nicholas Joel Ripley et al., 2021) mentioned that eccentric exercises, such as the Nordic Hamstring Exercise (NHE) and the FIFA11/FIFA11+ warm-up program, are more effective due to their easier adherence compared to other interventions. However, they recommended that eccentric exercises should be prescribed, starting with low intensity and progressively increasing.

The timing and method of incorporating eccentric exercises into rehabilitation are critical factors. In the early stages, the Askling-L protocol shown in Figure 4 is considered a safer option (Severini, Holland, Drumgoole, Delahunt, & Ditroilo, 2018). Rehabilitation can progress from bilateral to unilateral exercises and to higher-load exercises such as NHE (Hickey et al., 2022; Hickey et al., 2020). In their RCT, (Nicholas J Ripley et al., 2023) examined three groups to investigate the contribution of adding NHE and sprinting to a standardized lower extremity rehabilitation program. The NHE and Sprint groups showed significant improvements compared to the control group, with the NHE group demonstrating superior results over the Sprint group.

NHE is known as a supra-maximal exercise. Recent systematic reviews have indicated that reducing the intensity of NHE does not diminish its effectiveness (Cuthbert et al., 2020). Based on this finding, it can be concluded that athletes may find it easier to adapt to NHE. The Askling-L protocol is a preferred exercise option in the early stages; however, (Vermeulen et al., 2022), in their RCT, found that accelerating the initiation of 'lengthening' exercises in the Askling-L protocol during HSI rehabilitation in male athletes did not improve the time to return to sport or reduce the risk of re-injury.

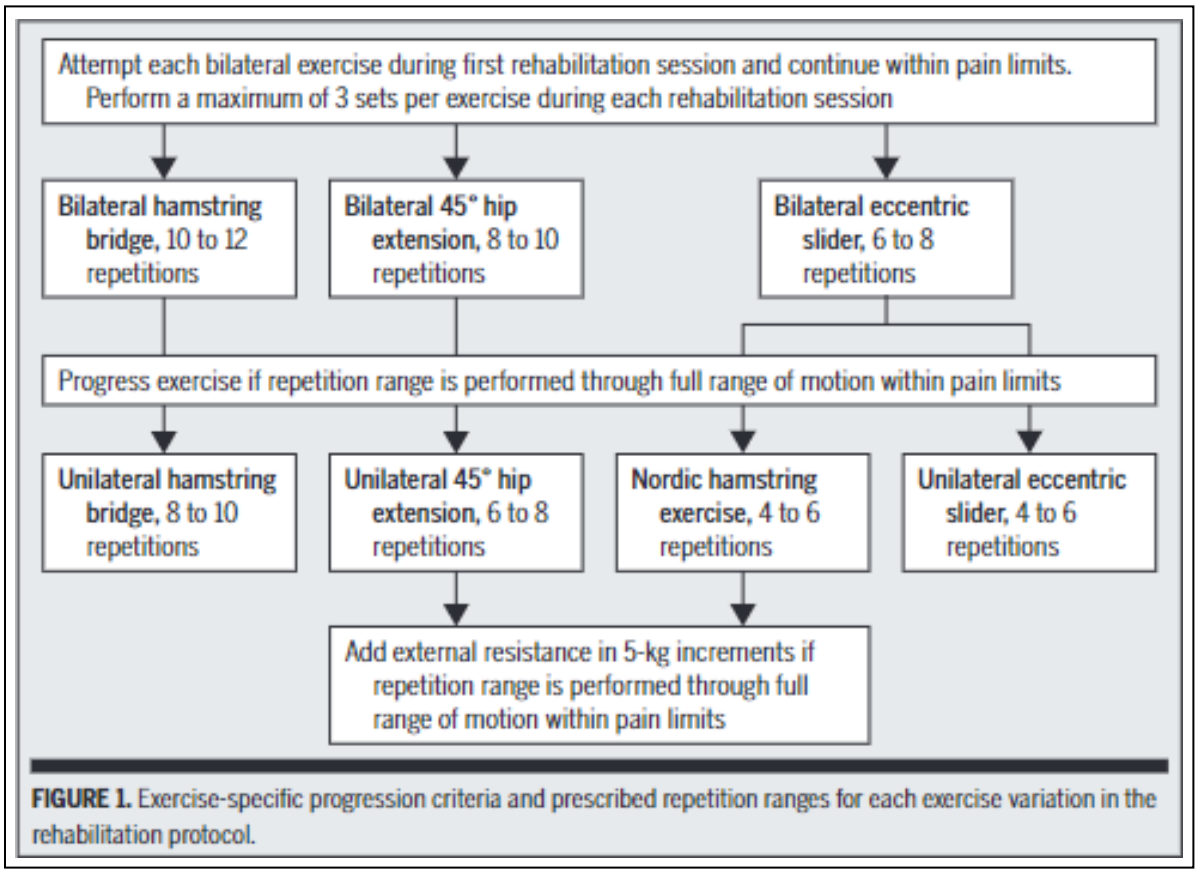

Figure 3. Sample eccentric exercise program (Hickey et al., 2020).

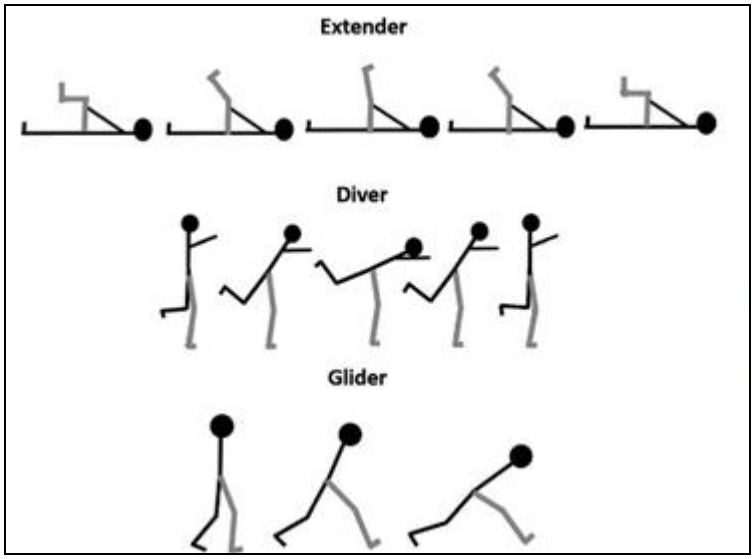

Figure 4. Graphical explanation of the Askling L-Protocol. In the Extender (EX) exercise, the aim is to improve the flexibility of the participant's hamstring muscles. The participant must hold the hip in flexion from a supine position while fully extending the knee. The Diver (DV) exercise challenges pelvic and trunk stabilization while building strength. The participant must simulate a diving motion while standing on one leg. The Glider (GL)

exercise loads the hamstrings through controlled lengthening. It requires the participant to perform a supported split, engaging the hamstring muscles (Severini et al., 2018).

Flexibility Exercises

Exercises aimed at improving hamstring flexibility are incorporated into rehabilitation programs to address deficits in hip flexion and knee extension range of motion (ROM) observed immediately after an HSI (Hickey et al., 2022). In their systematic review and meta-analysis on hamstring strength and flexibility post-HSI, Maniar, N. et al. found that deficits in isometric strength and flexibility (measured by passive straight leg raise) generally resolved within 20 to 50 days after HIS (Maniar, Shield, Williams, Timmins, & Opar, 2016). However, Hickey, J. et al., in their recent review, stated that these acute ROM deficits typically improve within the first two weeks following HSI and do not require direct intervention (Hickey et al., 2022). Although the effectiveness of flexibility exercises is unclear, various rehabilitation programs in the literature include exercises to improve flexibility (e.g., supine active knee extension) and dynamic hamstring mobility (Askling, Tengvar, Tarassova, & Thorstensson, 2014; Hickey et al., 2022; Maniar et al., 2016; Mendiguchia et al., 2017). In an RCT conducted on 20 male university athletes, (Wan et al., 2021) concluded that increasing hamstring flexibility or strength could help reduce the risk of hamstring injury during sprints in recreational male athletes. Based on the results of this study, while flexibility exercises may not play a clear role in rehabilitation, they could contribute to preventing re-injury.

Agility and Core Stabilization Exercises

Current literature on hamstring rehabilitation suggests that incorporating agility and core stabilization exercises into the rehabilitation program can reduce the time to return to sport and re-injury rates (Askling et al., 2014; Erickson & Sherry, 2017; Hickey et al., 2022; Jankaew, Chen, Chamnongkich, & Lin, 2023; O'Sullivan, Preszler, & Tanaka, 2022; Silder et al., 2013). (Hickey et al., 2022) reported that a rehabilitation concept focused on agility and core stabilization resulted in fewer re-injuries compared to a relatively conservative concept involving hamstring strengthening and stretching. In a meta-analysis, (Jankaew et al., 2023) demonstrated that a hamstring strengthening program combined with core stabilization and agility exercises prevented re-injury during a one-year follow-up period, although it was not associated with time to return to play (TTRTP).

(O'Sullivan et al., 2022) highlighted that increased anterior pelvic tilt in female athletes is associated with HSI, and consequently, strengthening the muscles responsible for core stabilization (e.g., transversus abdominis, gluteus maximus, and medius) should be included in the early phases of HSI rehabilitation, especially for female athletes. In an RCT involving 31 athletes with acute HSI, (Silder et al., 2013) applied a modified PATS (progressive agility and trunk stabilization) rehabilitation program and a PRES (progressive running and eccentric strengthening) program. The study reported similar outcomes in muscle healing and function between the two groups after the rehabilitation program.

However, despite meeting the return-to-sport criteria, athletes in both rehabilitation groups continued to

show signs of injury on MRI after completing the rehabilitation. These findings suggest that agility training and core stabilization exercises are as important as eccentric exercises in the rehabilitation of HSI.

Conclusion

In light of the current literature, exercise prescription forms the cornerstone of HSI rehabilitation. An effective rehabilitation plan should include a progressive running program, eccentric strengthening exercises—especially the Askling L protocol in the acute phase and Nordic exercises in the later stages—along with agility training and core stabilization exercises. Although the effectiveness of flexibility exercises remains debatable, incorporating them into the rehabilitation program poses no harm. Furthermore, this review provides clear evidence of the effectiveness of all other exercise interventions, apart from flexibility exercises, in reducing the risk of HSI re-injury and shortening the time to return to sport (Biz et al., 2021; Cuthbert et al., 2020; Hickey et al., 2022; Hickey et al., 2020; Jankaew et al., 2023; O'Sullivan et al., 2022; Nicholas J Ripley et al., 2023; Nicholas Joel Ripley et al., 2021).

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