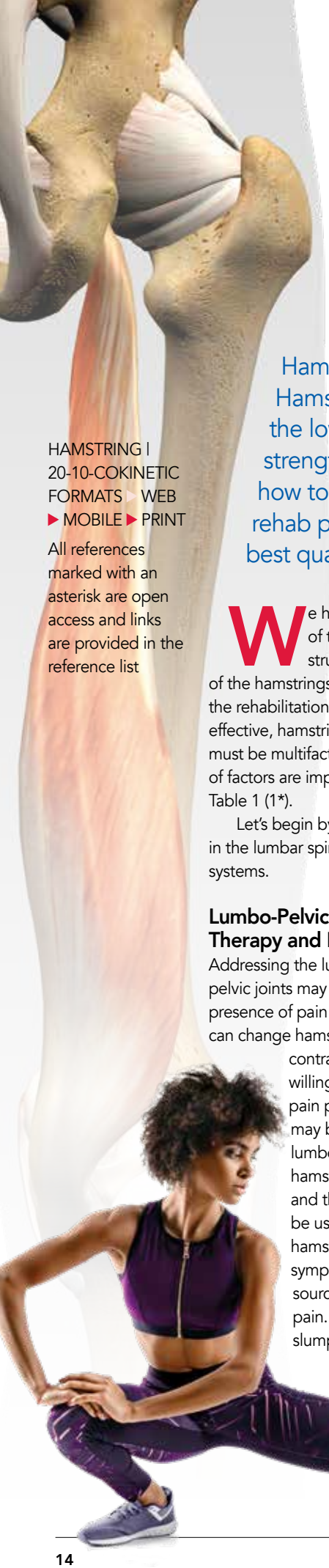

HAMSTRING INJURY
PART 2: REHABILITATION

By Dr Chris Norris PhD, MCSP

Hamstring injuries are common in sport, as are injury recurrence rates. Hamstring injury rehabilitation requires a multifactorial approach involving the lower spine and pelvis, neuromobilisation and hamstring lengthening and strengthening. This article sets out the aspects that need to be addressed and how to address them so that you will be able to create a personalised hamstring rehab programme that will give your patient the strength and confidence for the best quality return to play. Read this article online https://bit.ly/33p2fUu

HAMSTRING | 20-10-COKINETIC FORMATS ▶ WEB ▶ MOBILE ▶ PRINT

All references marked with an asterisk are open access and links are provided in the reference list

We have seen in Part 1 of this article that the structure and function of the hamstrings is used to guide the rehabilitation process. To be truly effective, hamstring rehabilitation must be multifactorial, and a number of factors are important, as shown in Table 1 (1*).

Let's begin by looking at changes in the lumbar spine, pelvis and neural systems.

Lumbo-Pelvic Manual Therapy and Neurodynamics

Addressing the lumbar spine and pelvic joints may be important as the presence of pain referred into the leg can change hamstring strength, muscle contraction timing and willingness to bend. Manual pain provocation tests may be used to clear the lumbo-pelvic region in the hamstring-injured patient, and the slump test may be used to differentiate hamstring and sciatic nerve symptoms as the primary source of posterior thigh pain. Additionally, the slump movement may be used as a treatment technique to facilitate nerve length and mobility (neurodynamics). Neural tension may both increase stretch resistance and limit total movement range.

The slump test is positive where the patient's posterior thigh pain is reproduced in the final slump position and reduced with cervical extension – an action which has no effect on the hamstrings but does change tension in the neural structures of the posterior thigh. The test has been shown to be positive in sportsmen and women (rugby players) who have suffered a number of hamstring tears in the past 2 years (2*). In addition, quality of return to play (RTP) is enhanced (fewer missed matches) when the test is used as a stretch within a rehabilitation programme (3*). Including the slump test modified as a neuromobilisation technique (slider exercise) has been recommend for athletes who have suffered a hamstring injury and feel a lack of free movement when running even in the presence of a negative straight leg raise (SLR) and slump test (1*).

Nerve sliding (gliding) of this type involves movement of at least two joints with one lengthening the nerve and the other shortening it. The combination of lengthening and shortening maintains the overall nerve length but improves nerve motility. In the case of the posterior thigh, we move the distal tissues (limb) while maintaining the position of the proximal tissues (spine) and then reverse the sequence. Whereas sustained nerve tension increases intraneural (within the nerve) pressure and reduces local blood flow, sliding (by maintaining overall nerve length) avoids these changes.

For the classic slump test or stretch, the subject sits on a stool and links their arms behind their back (Fig. 1). The action is to gently flex the spine, beginning with the neck. At the same time one leg is straightened and the foot and ankle pulled up (dorsiflexed). Components of this action may be used individually at first, then built up into a full sequence. If one leg is very tight, the knee on that side can be bent and gradually worked towards straightening, easing into the tightness but not forcing the movement. Supporting the foot of the tight leg on the floor by placing it on a shiny piece of paper is also helpful. With the weight of the leg taken through the floor, the subject slides the foot forwards and backwards, again gradually working towards the fully extended position. Maintain this position for 20–30 seconds and then release.

To perform the nerve slide (seated straight leg slider; Fig. 2), the subject begins in the classic slump position described above, ensuring that the subject's feet are clear of the floor. Keeping the spine flexed throughout

the exercise the neck is bent (flexed) to bring the chin down towards the breastbone (sternum). At the same time the knee is kept bent and the toes and foot are pointed (plantarflexion). To reverse the action, straighten the knee and draw the foot and toes up (ankle dorsiflexion and toe flexion) and at the same time look up at the ceiling (cervical extension). The sliding action is repeated rhythmically for 10 repetitions. Where there is a high degree of tightness, or where pain occurs, the exercise can be performed in two parts. Firstly, keeping the head still and moving the leg, and secondly keeping the leg still and moving the head. When both actions are pain free the two actions may be combined.

This straight leg sliding technique has been shown to increase range of motion (ROM) of the hamstring muscles (measured by SLR) without the need for separate hamstring stretching. Looking at a group of soccer players Castellote-Caballero et al. (5) used straight leg sliding for three periods over 1 week. Each exercise was practised for 60s for 5 repetitions. Average scores for SLR testing for the control group (no sliding) went from 58.9° to 59.1°, whereas the intervention group (neural sliding) went from 58.1° to 67.4°.

Mobilisation of the lumbar spine has been shown to increase ROM in the SLR test and change sympathetic nervous system activity in the limb (6), and it is recommended that this technique be used to modify patient symptoms with a view to pain modulation. Although lumbo-pelvic examination and treatment may be appropriate for any patient with hamstring injury, it is likely that the MRI-negative patient (that is, one where there is no visible muscle damage on an MRI scan) may especially benefit because of the presence of posterior thigh pain in the absence of local tissue change.

Lumbo-Pelvic Neuromuscular Control

Improvement in lumbo-pelvic control has been suggested to reduce hamstring demand and, therefore, potential for injury (1*). In addition, a trunk-stabilisation programme has been shown to reduce hamstring injury recurrence rate (7*) and a balance training programme to reduce hamstring injury rate in women's professional football (8). Although many athletes successfully compete at very high levels with suboptimal static and dynamic postures, in elite sport where fractions of a second matter, optimising control of the lumbo-pelvic region onto which the hamstrings take attachment would seem logical. Control of lumbo-pelvic alignment in the frontal plane can focus on actions based around the Trendelenburg test (pelvic alignment in single-leg standing). In the sagittal plane forward bending and lifting actions (above) can be used to optimise pelvic tilt. These actions should be progressed in terms of overload and complexity but must be paralleled with good exercise instruction and neurobiology re-education to reduce the chance of hypervigilance following injury.

Table 1: Multifactorial components of hamstring rehabilitation.
After Brukner et al. Recurrent hamstring muscle injury: applying the limited evidence in the professional football setting with a seven-point programme. British Journal of Sports Medicine 2013;48(11):929–938 (1)

Component	Clinical reasoning
Biomechanics	Foot, lower limb and lumbo-pelvic alignment
Neurodynamics	Single leg raise and slump testing
Neuromuscula control of lumbar spine	Lumbo-pelvic control and strengthening
Eccentric-biased strengthening	Varying movement range and muscle length
Running overload	Varying direction and speed; Task/sport specific
Stretching	Restoration of symmetry of motion range in static and dynamic task/sport-specific actions

TO BE TRULY EFFECTIVE, HAMSTRING REHABILITATION MUST BE MULTIFACTORIAL

Eccentric-Biased Strengthening

Research studies have consistently supported the notion that various forms of eccentric hamstring exercise are essential for prevention and rehabilitation of hamstring muscle injury. Injury commonly occurs at the end of the swing phase of sprinting when the hamstring muscles are lengthening either through eccentric contraction or isometric contraction with passive stretch (see Part 1 of this article). Rehabilitation must match this muscle contraction type and joint angle position, so eccentric work (high loads at longer muscle–tendon lengths) and/or isometric work at lengthened positions would seem logical.

Figure 1: Slump test

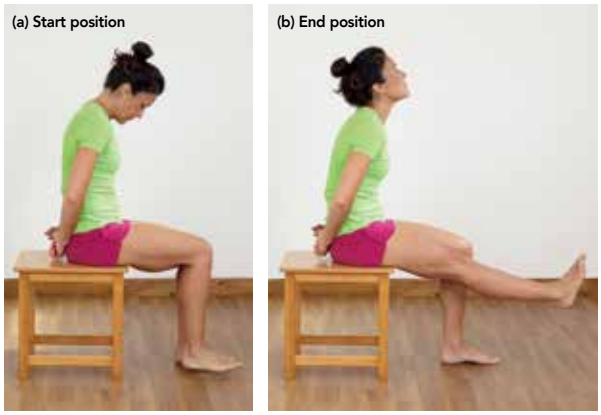

Figure 2: Straight leg slider

Nordic Hamstring Exercise

The Nordic hamstring exercise (NHE) has been shown to reduce injuries by 60% and reinjury by 85%, when used in a progressive 10-week programme (9). Progressive eccentric strengthening of this type is thought to address eccentric strength deficits, muscle–tendon atrophy and scar tissue within the hamstrings (10*). The NHE may shift the optimum angle for torque generation towards a longer hamstring length, mimicking the limb position at terminal swing just before heel contact, a point at which injury has been shown to occur (11).

The NHE has also been shown to be preventive of hamstring injury in male soccer players. Looking a 259 players, Hasebe et al. compared a NHE group to a control group not using the NHE but matched for all other training variables (12). Over a 27-week period the injury rate per 10,000 playing hours of the control group was 1.04/10,000h but down to 0.88/10,000h in the NHE group, resulting in a significant reduction in time lost.

A recent systematic review and meta-analysis showed a reduction in the injury risk ratio (relative risk) of 0.49† when programmes included the NHE, demonstrating that programmes which include the NHE reduce hamstring injuries by up to 51% (13*). The method by which the NHE prevents injury would seem to be a combination of increased eccentric strength and increased biceps femoris long head fascicle length (13*). Shorter length of the biceps femoris long head has been associated with increased hamstring muscle injury (14), and (as highlighted above) hamstring muscle injury is more common in late forward swing of a sprinting action when the hamstrings are acting eccentrically. Isometric hip extension using the single-leg Roman chair hold may be used together with, or as an alternative to, the NHE depending on subject requirements as both have been shown to increase biceps femoris long head fascicle length (15). The hip extension is more suited to endurance (isometric holding time) whereas the NHE is more demanding for repetitions. In addition, high-load isometrics may improve motor unit recruitment within the hamstrings (16).

The NHE is an intense muscle contraction, giving rise to muscle adaptation but with the likelihood of delayed onset muscle soreness. Progressive programmes should begin cautiously with one session each week initially (weeks 1–3) building to two sessions per week (weeks 2–5) and finally three per week (weeks 3–10) with one session per week for maintenance thereafter. Variation in the prescription is dependent on subject reaction to the exercise intervention.

Although the NHE is a vital component of rehabilitation it should not be used in isolation as it has a number of disadvantages. In general, it is practised bilaterally, not reflecting the unilateral nature of hamstring injury. Also, it is a single-joint (uniarticular) action whereas the hamstring muscles as a group are biarticular, and normally the NHE is performed at slow speeds. Progression of exercise must include training volume (frequency, intensity, time and type) and velocity at multiple joint angles. Slow controlled eccentrics should progress in parallel with general lower limb and lumbo-pelvic resistance training and motor control complexity. Ultimately power and speed-based actions (plyometrics) should be used together with skill-based actions reflecting the sport or employment of the subject.

The NHE begins in high kneeling with the ankles fixed (Fig. 3 and Video 1). The traditional action is to keep the hip fixed and angle the body forwards

Figure 3: The Nordic hamstring exercise (NHE)

Figure 4: Box drop

from the knee. The aim is to lower the body under control into a prone position, taking the final body weight of the final degrees of movement onto the hands. The action may be unloaded using a fixed strap (partner), elastic power loop (fixed point), or with the subject placing their hands on a Swiss ball and rolling it away from themselves.

From the same starting position, a bent knee back extension action may be performed, pulling from the hip and keeping the spine straight to begin. This action targets the hamstring higher up into the buttock, using an active pelvic tilt. It may be combined with or used separately to the traditional eccentric only version.

Deceleration Drops

Deceleration drills involve dropping into a bent-hip and -knee (squat) position either unilaterally or bilaterally. Initially this may be achieved by standing tall and simply dropping into a half-squat position. Firstly, this is performed on both legs together (squat position) and then progressed to one leg leading (lunge position). These actions may be progressed to lunge, hop and jogging actions to eventually mimic the straight-leg heel contact position of terminal swing phase of running.

The flat floor position may be changed to a box-drop position, when the action is to jump down and initially hold the position (Fig. 4). This action progresses to drop, land and move in forward, sideways, or rotary actions. These actions represent in-place (staying on one spot), short-response (2 or 3 hops or steps) or long-response (multiple steps or hops) plyometrics. These actions can emphasise force generation (acceleration) or force acceptance (deceleration) depending on training requirements.

General Exercises

Deadlift Variations

The straight-leg (Romanian) *deadlift* uses a fixed leg position either with the legs straight (knees locked) or slightly bent (knees soft) (See deadlift technique in Video 2). The action is to keep the spine straight and lift the body from the hip. Initially body weight alone is used (arms behind the tail or behind the head), but resistance may be added from a barbell, kettlebell or dumb-bells. As an alternative, the *arabesque* may be viewed as a single-leg version of the straight-leg deadlift. The leg to be trained stays with the foot on the floor (leg vertical) and the other leg lifts (leg horizontal). There are a number of versions of this action. In yoga, this is one of the warrior poses and the final position is with the lifted leg, trunk and arms horizontal to emphasise balance. This action may be performed standing on one leg with the arms lifted above the head. The movement is to keep the lifting leg, trunk and arms rigid and tip forwards into a 'T' position. The hands may be placed on a wall for balance. The diver is the same action, but the arms reach downwards to touch a stool or gym bench and then the body is moved back to the starting position focusing on repetitions and strength (Fig. 5 and Video 3).

Video 1: Nordics. Nordic hamstring exercise with variation for re-strengthening hip extensor musculature (Courtesy of YouTube user Norris Health) https://youtu.be/zVC9x9fcWZg

Video 2: Re-educating bending following low back pain (Courtesy of YouTube user Norris Health) https://youtu.be/-kGdwtfdRwY

Bridge-Type Movements

Bridging actions use the hip extensors and spine extensors from a supine lying position. For the slide-board leg-curl, the subject lies on their back with their foot on a slide board, piece of shiny paper on a carpet, cloth on a wooden floor, or seat of a rowing machine. The action is to slide the foot out from a bent knee position to straight leg and return. Single-leg or

●● ADDRESSING THE LUMBAR SPINE AND PELVIC JOINTS MAY BE IMPORTANT ●●

Video 3: Hamstring rehabilitation. Diver, extender, and slider exercise used for rehabilitation & training of hamstrings injury
(Courtesy of YouTube user Norris Health)
https://youtu.be/cVyZqMcrbok

bilateral-leg action may be used (Fig. 6 and Video 4).

The high bridge (gym-ball bridge) is performed from a crook (hook) lying position with one heel on a bench or chair, or a gym ball to provide an unstable surface. The action is to press the heel down to dig into the bench and lift the hips upwards. Again, unilateral or bilateral actions may both be used. Where the unilateral action is used, the pelvis must be kept level, not allowing the hip on the non-active side to trail. This action may be modified into the eccentric leg-curl on a gym ball. The action now is to press the heels into the gym ball to lift the pelvis and to straighten the legs and then lower the trunk (eccentric only) or to straighten the legs and then bend them again (eccentric-concentric).

The loaded bridge may be performed with the shoulders on a gym bench and the knees bent. A weight disc is placed on the lap, or a barbell is placed over the pelvis with the bar (padded) level with the top of the pelvis. The action is to lift the pelvis into a bridge position, finishing with the thigh horizontal. The foot must press directly downwards (hip extension) rather than outwards (knee extension).

Video 4: Bridge exercise & variations (Courtesy of YouTube user Norris Health)
https://youtu.be/dd1AR1gzsX8

Figure 5: Single-leg actions

Figure 6: Bridging actions

Overload Running

Initially following injury, active muscle lengthening may be imposed by walking (treadmill or set distance/time when land based). At this stage, pain tolerance can be used to limit training intensity and volume with short timescales of 5–10 minutes and pain intensity of 3 or 4 out of a maximum of 10 (numerical rating scale). Early activity of this sort (from day 1 with more minor grade 1 or 2 functional injuries) prevents the neuromuscular inhibition which is often seen following muscle injury. Progression can be by time and/or distance, speed, stride length and incline. Table 2 outlines a programme of progressive phases from simply treadmill walking through to full running.

Treadmill walking gives way to gentle pain-free jogging and then scout pace (walk-jog-walk). Manual resistance is used as isometric exercises progress to concentric exercises using both bent-leg (prone lying knee flexion) and straight-leg (SLR position) actions. The running speed increases gradually ensuring that the subject can tolerate the increase load on the injured leg. Graded exposure is used, increasing and reducing distance and speed depending on symptoms initially. Manual concentric strength work is progressed to assisted bodyweight work using concentrics and eccentrics. Deadlift actions (straight leg and bent leg) are performed to reduced range (bench or stool level) and using band assistance initially. NHE can be begun with belt/resistance band assistance, progressing to Swiss ball roll-out as pain allows. Running gradually increases for pace, distance, and incline. As function improves the symptom contingent nature of training can progress to time contingent work.

Treadmill work gives way to normal running on a runway in the gym or sports field. Longer (50m) runs at

slower pace gradually progress to shorter (30m, 20m) at increased pace. The next progression is to focus on acceleration and deceleration drills and to introduce sagittal (side step) and multidirectional (zig-zag and cutting) loading. The final progression before RTP will depend on the sport and player's position, or subject's work time and daily living actions. Functional progressions are used to replicate the actions to be encountered in sport/daily living with the aim of building final load tolerance and confidence in the limb.

Table 2: Progressive walk/run programme for hamstring rehabilitation

Phase	Activity
1	● Isometrics to prevent neuromuscular inhibition ● Reduce pain maintain ROM ● Walk on treatment 4–6mph until able to jog
2	● Run at speed without symptoms – patient led rehab ● Introduce concentric exercises using manual resistance bent/straight leg ● Swing through within comfortable range ● Increase running speed progressively
3	● Increasing speed on treadmill to higher speed ● Concentric eccentric RDL low weight pull through with band ● NHE using Swiss ball roll-out ● 1km run outside ● 4min high speed (4.5m/s)
4	● Treadmill higher speed, 30s on, 30s off ×6 reps – build to 5m/s and 6m/s ● Band-assisted NHE ● Increase rate of force development using weights
5	● Runway work 20m acceleration, 20m hold, 20m deceleration ● Increase speed and reduce distance to 15m, then 10m ● Use acceleration/deceleration to progress rate of torque development ● Sagittal training, progressing to cutting and multidirectional work ● Return to protected training and limited RTP ● Focus on load management

NHE, Nordic hamstring exercise; RDL, Romanian deadlift; ROM, range of motion; RTP, return to play

Hamstring Stretching

Current practice in both prevention and rehabilitation of hamstring injury places less emphasis on stretching than in previous years as the evidence for its importance is limited. Interestingly, the active SLR has been used as an assessment of both flexibility and feelings of general insecurity in the limb following injury. The test (H-test) is performed by the subject lying supine with the upper body and contralateral leg stabilised and the ipsilateral knee locked and held immobile in a brace. The subject performs a maximum number of rapid SLR actions and rates their experience on a VAS scale. The H-test was shown to be sensitive to detect remaining signs of injury in MRI-confirmed acute hamstring strain when standard clinical examination (palpation pain, manual strength tests and passive SLR) had failed to do so (17).

ROM should be restored to that required by the subject's activities to ensure pain-free unrestricted movement. The use of ROM combined with controlled contraction (eccentrics) more accurately reflects the functional requirements of the hamstrings than static stretching alone. A series of three lengthening actions (L-protocol) were compared to traditional contraction and static stretching (C-protocol) in elite sprinters and jumpers (18). The L-protocol gave a mean time for return to competition of 49 days compared to 86 days for the C-protocol. The three exercises used are shown in Table 3 and Video 3. Activity-specific actions of this type can be designed using basic movement analysis of sports and daily actions with an emphasis on 'strengthen and lengthen' exercise. These can progress to functional activities pre-competition which involves all types of muscle work.

Where traditional stretching exercises are used, they must take account of pelvic action and the action of the two-joint muscle. In addition, relative flexibility may dictate that the majority of the stretching force is imposed on the lumbar spine in toe-touching type movements.

Table 3: Hamstring lengthening exercise protocol (L-protocol) Adapted from Askling et al. Acute hamstring injuries in Swedish elite sprinters and jumpers: a prospective randomised controlled clinical trial comparing two rehabilitation protocols. British Journal of Sports Medicine 2014;48(7):532–539 (18)

Extender: Active knee extension exercise holding the thigh still (90° hip flexion) and extension of the leg for 3 sets of 12 repetitions.

Diver: Modified arabesque exercise. Single-leg standing on injured side, with knee soft (10–20° flexion). Reach forwards, flexing at the hip and stretch the arms out and free leg backwards, allowing back leg to bend: 3 sets of 6 reps.

Glider: Modified front splits. Stand with the injured leg forwards holding onto a bar. Slide the unaffected leg backwards using a cloth/slide pad beneath the foot keeping the body weight on the front (injured) leg. Move back to the starting position using the arms, not pulling through the injured leg.

●● RESEARCH STUDIES HAVE CONSISTENTLY SHOWN THAT ECCENTRIC HAMSTRING EXERCISES ARE ESSENTIAL FOR PREVENTION AND REHABILITATION OF HAMSTRING MUSCLE INJURY ●●

Flexibility may begin with active knee extension described above. The advantage of this movement is the reciprocal innervation gained from quadriceps action, and the control that the athlete has over the movement. In addition, the back is supported throughout the action. The tripod stretch is also a useful exercise which requires a combination of pelvic stability with hamstring flexibility in a sitting position. The arms support the spine and encourage an upright body position.

Closed Chain Actions

Closed chain exercises for the hip extensors may be performed by modifying many common exercises. Leg rowing is a useful exercise. The athlete sits on a towel (on a wooden floor) or plastic tray (on a carpeted floor) with the feet fixed. The action is to pull the body forwards by hamstring action, mimicking a rowing position. Sitting astride a gym bench or 'form', the athlete digs the heels into the ground and again pulls the body forwards using leg strength alone. Both of these actions may be performed unilaterally or bilaterally. The slide trainer may also be used for sagittal leg-pumping actions with the knees straight or bent. The sitting leg-press weight-training apparatus may be used for the sprint kick exercise. Instead of sitting on the bench, the athlete turns around and places the shoulders against the chair back, and the ball of the foot on the machine pedal. The action is to press the machine pedal with a combined hip and knee extension action. Bridging actions may be performed with the foot on a moving surface (skateboard), bench, or Swiss ball as above for variety and resistance increased by adding weight to the hips (barbell) and placing the shoulders on a bench.

RTP Criteria

As rehabilitation progresses, functional training increases with actions that mimic the demands of an activity or sport. The question then arises as to when a person can resume their sport/activity or when a player is fit for competition. Criteria for RTP following hamstring muscle injury have been agreed in a consensus statement involving 58 experts in the field of hamstring injury management in soccer (19*). RTP is a shared decision between those involved in player management (physician, physiotherapist, fitness trainer and coach) and both physical and mental attributes are involved. Firstly, there should be an absence of *pain* to palpation, and an absence of pain during strength and flexibility tests. In addition, there should be no pain during or after sport-specific functional testing. Hamstring *strength and flexibility* should be similar on both the injured and non-injured sides. *Functional* performance on field testing should be positive, reaching preinjury levels (able to perform tasks selected relevant to sports and sport position). Maximal sprints and sprints under fatigue conditions are usually included as part of functional training and testing to mimic match play. Finally, *psychological readiness* to play must be established with the player demonstrating a positive mental attitude and no avoidance behaviour.

RETURN TO PLAY IS A SHARED DECISION AND INVOLVES BOTH PHYSICAL AND MENTAL ATTRIBUTES

References

1. Brukner P, Nealon A, Morgan C et al. Recurrent hamstring muscle injury: applying the limited evidence in the professional football setting with a seven-point programme. **British Journal of Sports Medicine 2013;48(11):929–938** Open access https://bit.ly/2LYTZSO
2. Turl S, George K. Adverse neural tension: a factor in repetitive hamstring strain? **Journal of Orthopaedic & Sports Physical Therapy 1998;27(1):16–21** Open access https://bit.ly/3iVdslM
3. Kornberg C, Lew P. The effect of stretching neural structures on grade one hamstring injuries. **Journal of Orthopaedic & Sports Physical Therapy. 1989;10(12):481–487** Open access https://bit.ly/2CKawZM
4. Norris C. Sports and soft tissue injuries, 5th edn. **Routledge 2018** ISBN 978-1138106598 (Print £44.55 Kindle £42.32). Buy from Amazon https://amzn.to/2CLySSY
5. Castellote-Caballero Y, Valenza M, Martín-Martín L et al. Effects of a neurodynamic sliding technique on hamstring flexibility in healthy male soccer players. A pilot study. **Physical Therapy in Sport 2013;14(3):156–162**
6. Szlezak A, Georgilopoulos P, Bullock-Saxton J et al. The immediate effect of unilateral lumbar Z-joint mobilisation on posterior chain neurodynamics: a randomised controlled study. **Manual Therapy 2011;16(6):609–613**
7. Sherry M, Best T. A comparison of 2 rehabilitation programs in the treatment of acute hamstring strains. **Journal of Orthopaedic & Sports Physical Therapy 2004;34(3):116–125** Open access https://bit.ly/3g8dTr7
8. Kraemer R, Knobloch K. A soccer-specific balance training program for hamstring muscle and patellar and Achilles tendon injuries. **The American Journal of Sports Medicine 2009;37(7):1384–1393**
9. Petersen J, Thorborg K, Nielsen M et al. Preventive effect of eccentric training on acute hamstring injuries in men's soccer. **The American Journal of Sports Medicine 2011;39(11):2296–2303**
10. Thorborg K. Why hamstring eccentrics are hamstring essentials. **British Journal of Sports Medicine 2012;46(7):463–465** Open access https://bit.ly/3iVeA90
11. Schache A, Kim H, Morgan D et al. Hamstring muscle forces prior to and immediately following an acute sprinting-related muscle strain injury. **Gait & Posture 2010;32(1):136–140**
12. Hasebe Y, Akasaka K, Otsudo T et al. Effects of Nordic hamstring exercise on hamstring injuries in high school soccer

players: a randomized controlled trial. **International Journal of Sports Medicine 2020;41(03):154–160**
13. van Dyk N, Behan F, Whiteley R. Including the Nordic hamstring exercise in injury prevention programmes halves the rate of hamstring injuries: a systematic review and meta-analysis of 8459 athletes. **British Journal of Sports Medicine 2019;53(21):1362–1370** Open access https://bit.ly/34atxzP
14. Timmins R, Bourne M, Shield A et al. Short biceps femoris fascicles and eccentric knee flexor weakness increase the risk of hamstring injury in elite football (soccer): a prospective cohort study. **British Journal of Sports Medicine 2016;50(24):1524–1535**
15. Bourne M, Duhig S, Timmins R et al. Impact of the Nordic hamstring and hip extension exercises on hamstring architecture and morphology: implications for injury prevention. **British Journal of Sports Medicine 2017;51(5):469–477**
16. Macdonald B, McAleer S, Kelly S et al. Hamstring rehabilitation in elite track and field athletes: applying the British Athletics Muscle Injury Classification in clinical practice. **British Journal of Sports Medicine 2019;53(23):1464–1473**
17. Askling C, Nilsson J, Thorstensson A. A new hamstring test to complement the common clinical examination before return to sport after injury. **Knee Surgery, Sports Traumatology, Arthroscopy 2010;18(12):1798–1803**
18. Askling C, Tengvar M, Tarassova O et al. Acute hamstring injuries in Swedish elite sprinters and jumpers: a prospective randomised controlled clinical trial comparing two rehabilitation protocols. **British Journal of Sports Medicine 2014;48(7):532–539**
19. van der Horst N, Backx F, Goedhart EA et al. Return to play after hamstring injuries in football (soccer): a worldwide Delphi procedure regarding definition, medical criteria and decision-making. **British Journal of Sports Medicine 2017;51(22):1583–1591** Open access https://bit.ly/328TL2O.

Acknowledgement
All Figures are published with permission from Norris C. Sports and soft tissue injuries. Routledge 2018 (4)

† The risk ratio is a measure of association between two items (variables). If the risk ratio is close to 1 the incidence is about the same in both groups. Where the risk ratio is greater than 1 (>1) it suggests an increased risk, and where it is less than 1 (<1) the risk is reduced.

KEY POINTS

- Hamstring rehabilitation must be multifactorial.
- Testing the lumbar spine, pelvic joints and neural systems is important to rule out these structures as the primary source of pain referred to the posterior thigh.
- The slump test can be modified to a neuromobilisation exercise, which improves quality of return to play when used as part of a hamstring rehab programme.
- Improvement of lumbo-pelvic control through a trunk-stabilisation programme seems to reduce hamstring demand and hamstring injury recurrence.
- Eccentric hamstring exercises are essential for hamstring injury prevention and rehab.
- The Nordic hamstring exercise is very effective for reducing hamstring injury and reinjury rates.
- Overload running, hamstring stretching and closed chain actions can all form part of the hamstring rehab programme.
- Return to play should be through shared decision-making and criteria have been set out in the consensus statement concerning return to play after hamstring injuries in football (soccer).

DISCUSSIONS

- If you had a patient complaining of posterior thigh pain, what tests/checks would you do to determine the cause of that pain?
- How would you prepare a hamstring rehabilitation programme tailored to an individual patient?
- How would you assess when a patient is ready to return to their activity?

RELATED CONTENT

- Hamstring Injury Part 1: Anatomy, Function and Injury [Article] https://bit.ly/2UncJj8
- Role of the Thorax in Treatment of Recurrent Hamstring Injury [Article] https://bit.ly/2LT8zex
- The Hamstring Hustle: Rapid Return to Sport Versus Recurrence [Article] https://bit.ly/2yALD0A
- Hamstring Injury Patient Information Resources https://bit.ly/2yuUiS2

THE AUTHOR
Dr Chris Norris PhD, MCSP is a physiotherapist with over 35 years' experience. He has an MSc in Exercise Science and a PhD in Backpain Rehabilitation, together with clinical qualifications in manual therapy, orthopaedic medicine, acupuncture, and medical education.

Chris is the author of 12 books on physiotherapy, exercise, and acupuncture and lectures widely in the UK and abroad. He is a visiting lecturer and external examiner to several universities at postgraduate level.

He runs private clinics in Cheshire and Manchester and his postgraduate courses for therapists are on his website.

Email: cmn@norrishealth.co.uk
Twitter: https://twitter.com/NorrisHealth
YouTube: https://www.youtube.com/channel/UC0VExulacEqFW7gahk98Tuw
Website: http://www.norrishealth.co.uk/

Want to share on Twitter?

Here are some suggestions

Tweet this: To be truly effective, hamstring rehabilitation must be multifactorial https://bit.ly/33p2fUu
Tweet this: In hamstring rehab it is also necessary to address the lumbar spine and pelvic joints https://bit.ly/33p2fUu
Tweet this: The slump test improves RTP quality when used as a stretch with a hamstring rehab programme https://bit.ly/33p2fUu
Tweet this: Eccentric hamstring exercises are essential for prevention and rehab of hamstring muscle injury https://bit.ly/33p2fUu
Tweet this: Hamstring rehab requires functional progressions to build final load tolerance and confidence https://bit.ly/33p2fUu