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REHABILITATION

Hamstring injuries require triplanar assessment

Mechanisms of hamstring strain can be specific to activity, so context should be considered during rehab.

By: Robert Dowling, DPT, and Ron Hruska, PT

Hamstring discussions are some of the most common in orthopedic rehabilitative medicine. With the muscle's capacity to influence the pelvis, sacrum, hip, and lower leg, it makes sense that clinicians develop a thorough understanding of hamstring function. Unfortunately the literature rarely addresses hamstring function aside from the knee joint in the sagittal plane. While hamstring/quadriceps ratios and the focus on hamstrings in ACL rehabilitation is important, the role of the hamstrings at the pelvis in the transverse and sagittal planes is at least as important as, if not more important than, hamstring function at the knee.

Most commonly the hamstrings are described as flexors of the knee and rotators of the hip and tibia.1,2 EMG studies of gait reveal that the hamstrings are most active eccentrically in deceleration of the upper and lower leg during the last 20% of swing phase. Concentrically the hamstrings actively extend the hip and contribute to stability between 18% and 28% of stance phase.3

The semimembranosus and semitendinosus muscles both originate from the ischial tuberosity by a common tendon, along with the long head of the biceps femoris.1 The muscles then attach to the posteromedial surface of the tibia. The semitendinosus attaches distal to the semimembranosus, which also has ties into the deep fascia of the leg. The long head of the biceps femoris originates from the distal part of the sacrotuberous ligament and the posterior part of the ischial tuberosity. The short head originates from the lateral lip of the linea aspera, the proximal two-thirds of the supracondylar line, and the lateral intermuscular septum. Both heads insert into the lateral side of the fibular head and deep fascia of the lateral leg. Although not commonly discussed, the attachment of the biceps femoris to the sacrotuberous ligament is of critical importance and provides a direct link between the femur, lower leg, and sacrum.4-6

Common muscular descriptors

Skeletal muscles can be described by morphology, physiology, and function. Given the importance of the structure/function relationship, it is worth including a brief summary of the most common hamstring descriptors.

Morphologically and physiologically, Brunnstrom describes the hamstrings as type I, or slow twitch, muscle fibers.7 This type of muscle contains primarily red fibers as a result of mitochondrial density and myoglobin. These components make the muscle aerobic in nature and capable of sustaining low-level contractions for long periods of time. In contrast, type II-fast twitch, or white fiber-are described as more anaerobic in nature. The white color of these muscle fibers is a result of less mitochondria and myoglobin concentration.7

According to Janda's description, type I muscles have a predominantly tonic or postural function and tend to respond to dysfunction with hypertonicity or shortening.8-10 Type II muscles, such as gluteals, are classified as phasic and respond to dysfunction with weakness or hypotonicity.4,8 Janda's description of the hamstrings as primarily postural or tonic is most applicable to hamstring function at the pelvis instead of the knee, which is typically more involved with phasic activity.

Stabilization function

VanWingerden11 and Vleeming6 discussed this tonic stabilization function at length and further delineated tonic/postural function of the hamstrings into intrinsic and extrinsic stabilizers. Extrinsic function involves movement of the pelvis relative to the lower extremities, and intrinsic function relates to the balance between the innominates and/or pelvic ring. Intrinsic and extrinsic hamstring functions do not occur in isolation, but rather may occur simultaneously. An appreciation of these dual functions allows us to better understand mechanisms of injury and necessary components of functional rehabilitation. Hamstring strains in track, hockey, or even industry may stem from extremely different mechanisms and thus must be assessed and rehabilitated in the context of the demands and planes of motion specific to the activity in question.

Kinetics

Posturally, the most important hamstring function is control of innominate rotation in the sagittal plane. This function occurs in a force couple with the abdominal oblique muscles anteriorly and the gluteal muscles posteriorly. While seemingly simple, this force couple has a dramatic effect on respiration, lumbar lordosis, and surrounding hip musculature in all three planes.

In the presence of weak abdominals or hamstring injury, the pelvis will tip anteriorly in the sagittal plane and translate forward, thereby increasing the lordosis unilaterally or bilaterally. Because of the oblique anteromedial orientation of the sacroiliac joints, a unilateral or asymmetrical innominate rotation will be accompanied by rotation of the pelvis in the transverse plane to the contralateral side. Concomitant with this is the internal orientation of the hip on the side of anterior pelvic rotation. Hip rotation orientation changes by virtue of the iliofemoral ligament.

To summarize this cascade, an anterior rotation of the left innominate will cause the entire pelvis to rotate to the right and internally orient the left femur. From this position, compensatory motion at the femur must occur in order to orient the head to a forward and level position. Several common compensations that may result from this postural change include forward head, a lateral shift in the center of gravity, and imbalances in hip and shoulder rotation. Interestingly, the symptoms that cause patients to seek care arise most often in these areas of compensation and not in the area of biomechanical fault or dysfunction.

With regard to respiration, the anterior rotation of the pelvis changes the length/tension relationship of the abdominals and iliopsoas anteriorly and the gluteals posteriorly. This suboptimal position of the muscles affects the position and stability of the spine and ribcage. As the key muscle in respiration, the diaphragm's position and function are directly affected by the spine and ribcage.

If alterations in length/tension relationships occur or force couples become dysfunctional at any point in this chain, respiratory compensations must be made. The primacy of the respiratory drive necessitates the recruitment of any or all related muscular components until air exchange is sufficient. This often involves high levels of sustained recruitment in the accessory respiratory muscles, which also have attachments to the cervical spine, skull, ribs, and scapulae. The increased workload required of these muscles often results in symptoms in the head, neck, and upper quarter.

Transverse plane activity in any part of the kinetic chain is one of the most difficult areas of function to understand and therefore one of the least discussed. This trend is consistent when applied to the hamstrings. Although most texts include the rotary component in any list of hamstring functions, the description usually pertains only to the open chain function of the lower leg. However, the hamstrings' ability to stabilize and control femoral and pelvic rotation deserves more attention. As hip extensors, knee flexors, and participants in both internal and external rotation, the hamstrings are nearly unmatched in their contribution to trunk and pelvic stabilization.

The attachments of the hamstrings on both the medial and lateral sides of the knee joint optimally position them to assist in stabilizing the femur and pelvis while also contributing to dynamic transverse plane motion. Figuratively, this arrangement is similar to the reins used by a rider to control a horse. The rotatory component becomes even more important when force couples and length/tension relationships are disrupted by changes in position.

Dynamic control of the femur and pelvis in the transverse plane has an enormous impact on the adjacent joints. Proximally, the lumbar spine tolerates only very small amounts of rotation, anatomically. The intervertebral discs are also particularly susceptible to rotatory strain, not to mention the compression that accompanies any rotatory motion. Distally, the knee joint has a limited range through which it can rotate without significant strain on collateral and cruciate ligaments. In this more global view, then, limitations in the fine control and stability of the femur, particularly in the transverse plane, may contribute to rotatory strains proximally or distally.

The ability of the hamstrings to act as stabilizers and dynamic movers of the pelvis is of critical importance functionally. These phenomena may occur simultaneously and/or sequentially; however, increasing the demand for one function must reduce the capacity to perform the other function. An increase in the demand for dynamic hamstring function reduces the muscle's capacity for its stabilizing function, and vice versa. Further, as with any dynamic movement, limited functional ability of the prime mover results in increased use of agonists and synergists.

With this in mind, the previous example of an anterior and forward rotation of the hemipelvis creates several critical issues related to hamstring function and injury. The ipsilateral internal orientation of the femur will increase demand on the external rotators ipsilaterally in order to reorient the femur and foot, because failure to do so will cause the individual to trip or drag the toes on that side. As an external rotator, the long head of the biceps femoris must increase its activity, which may cause a strain of the biceps femoris or tightening of the iliotibial band. Interestingly, medial hamstring strains may also occur on the ipsilateral side. These strains happen as the medial hamstrings work to offset a hyperactive psoas, which inadvertently flexes the hip at midstance while trying to provide external rotation. Thus, the loss of a normal force couple in the sagittal plane (e.g., hamstring, gluteal, and abdominals), may create a compensatory overuse of the medial and or lateral hamstrings, which act in different planes across the hip/pelvis.

A second common hamstring dysfunction occurs with a loss of extensibility in the lower leg or a talocrural joint restriction. The loss of dorsiflexion brought about by both of these dysfunctions causes a reduction in hip extension and subsequent early heel rise. Lack of proper hip extension inadequately loads the hamstrings and limits their ability to function as stabilizers or movers at either attachment.

Examples

As mentioned earlier, functional demands on the hamstrings may vary greatly among patients, depending on activity and activity level. How a track athlete is injured and how he or she is rehabilitated will be different than a hockey player or industrial worker. In the clinic, an understanding of activity-specific hamstring function is critical to proper rehabilitation of each patient.

Hamstring injuries in track athletes and distance runners are common. Running is for the most part a sagittal plane activity. Therefore, we must consider the athlete's ability to dynamically control sagittal plane activity of the pelvis. The primary muscles involved in this control are the hamstrings, gluteals, and abdominals. A common mechanism for injury involves abdominal weakness, which allows for anterior rotation of the pelvis. This in turn passively places the hamstrings in a lengthened position as the ischial tuberosities rotate superiorly while the pelvis rotates anteriorly. Rehabilitation of this athlete then must address the sagittal plane of the hamstrings at the knee and pelvis. However, some of the transverse and frontal plane issues from the other examples must also be considered.

Despite the similar need to propel the body forward, the functional demands of the hockey player differ dramatically from the runner. Skating in hockey skates is primarily a frontal and transverse plane activity. Therefore proper function of hip abductors/adductors and pelvis/femoral rotators and stabilizers is critical. Hamstring function in this population will center more on rotatory stability of the femur and pelvis. Interestingly, gluteals and abdominals, like the hamstrings, have key roles in stabilizing the pelvis and producing dynamic transverse plane motion. The need for stability in these athletes is further increased by virtue of reduced friction from the ice compared to friction from solid ground. Rehabilitation of these athletes then must address the transverse and frontal planes primarily, and emphasize stability. The specific musculature used is very similar to the track athlete's, with the addition of the other hip rotators and abductors/adductors. However, the planes of motion and nature (stability versus mobility) of functionality are dramatically different. Unilateral stance, balance, and medicine ball exercises are excellent choices for these hockey players.

The industrial or factory worker presents biomechanical issues much different than the previous two examples. While the specific duties of factory work vary greatly, the work will usually involve some type of assembly where parts are loaded/unloaded or manipulated in some fashion. In this environment, patients commonly function with the feet in a relatively static position. Trunk rotation and lifting occur frequently above the pelvis as parts or machinery are moved. Flexion of the trunk is also common. In this scenario, hamstring function is oriented more toward the hip and pelvis in the sagittal and transverse planes. Although gross hamstring strains may not be as common in this population as in athletes, hip and low back pain is common. Dysfunction in these areas will center around the ability of the hip musculature to produce/control the necessary flexion and rotation. If these needs are not met, the forces will be transmitted to the lumbar spine, which does well in the sagittal plane but is poorly suited to withstand these forces in the transverse plane.

Posture and balance

Another issue present in all the examples, but particularly the industrial worker, is that of posture and muscular balance. As a function of hand dominance or workstation setup, workers may adopt a unilateral bias in standing, direction of rotation, reaching, or trunk flexion/ extension postures. Any of these biases can be a source of muscular imbalances, which may produce symptoms after sufficient repetition of activity. For example, a right-handed individual may adopt a bias toward right-legged standing. This posture will cause the center of gravity to shift to the right, then elongate the right hip abductors and external rotators while shortening those same structures on the left. If repetitive activity is carried out for extended periods, it is easy to see how hip or low back dysfunction may develop. The role of the hamstrings in all of this is important because of their ability to produce internal and external rotation as well as trunk flexion. Rehabilitation of these patients should focus on eliminating existing dysfunction and then restoring postural awareness and muscle balance, particularly in femoral and trunk flexion and rotation.

The role of the hamstrings is important because of their ability to stabilize the pelvis in the transverse and sagittal planes during trunk flexion and rotation.

Anatomically, the hamstrings are capable of producing both internal and external rotation as well as hip extension. The balance of musculature across the hip in all three planes is critical to successful function in sport and work activities. Disruption of the normal force couple in either the sagittal or transverse plane will have tremendous effects across the lumbar spine, pelvis, and lower extremities in all three planes of motion. In particular, insufficient strength of medial or lateral femoral musculature increases the demands on the hamstrings dynamically and limits their ability to act as stabilizers of the pelvis. Rehabilitation programs directed at the hamstrings must address the triplanar nature of the muscle in the environment in which it functions both as a prime mover and as a stabilizer.

Robert Dowling DPT, MDT, CSCS, is director of physical therapy at Advanced Physical Therapy Center in Hartland, MI, and lecturer/instructor in osteopathic manual medicine and lumbopelvic mechanics. Ron Hruska, MPA, PT, is owner of the Hruska Clinic in Lincoln, NE, and director of the Postural Restoration Institute, also in Lincoln.

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