

## High Hamstring Tendinopathy in Runners

Meeting the Challenges of Diagnosis, Treatment, and Rehabilitation

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**Abstract:** High hamstring tendinopathy is an uncommon overuse injury seen in running athletes. Patients typically report deep buttock or thigh pain. A detailed physical examination and, occasionally, imaging studies are necessary to confirm the diagnosis. Rehabilitation involves soft-tissue mobilization, frequent stretching, and progressive eccentric hamstring strengthening and core stabilization exercises. In recalcitrant cases, an ultrasound-guided corticosteroid injection into the tendon sheath can be helpful, and, occasionally, surgery may be necessary to release the scar tissue around the proximal hamstring muscles and the sciatic nerve.

High hamstring tendinopathy is an overuse injury often seen in middle- and long-distance runners and less commonly in other running athletes. Acute midhamstring muscle-tendon junction injuries are more common in sprinters. Patients who have high hamstring tendinopathy typically report deep buttock or posterior thigh pain brought on during acceleration and at faster speeds. Histologic evaluation shows a chronic tendinopathy with dense fibrosis and, in some cases, hyaline degeneration at the attachment of the hamstring to the ischial tuberosity.<sup>1</sup> This fibrosis can entrap components of the sciatic nerve, causing radicular-type neuropathic pain in the involved extremity.<sup>1</sup>

Limited information exists in the literature on diagnosis and treatment of high hamstring tendinopathy. Our clinical experience during the past 12 years and the paucity of available research has led us to investigate the biomechanics, causes, diagnosis, and treatment of this condition.

### An Illustrative Case

**History.** A 32-year-old female elite middle-distance runner presented to our sports medicine clinic with right upper hamstring and buttock pain related to running. She had seen another physician for low-back and buttock pain 2 years earlier. That physician presumed the cause to be a lumbar disk bulge. She was treated with lumbar epidural injections and physical therapy. Her low-back pain improved sufficiently to allow her to compete in the Olympics. Although the back pain resolved, the upper-thigh and buttock pain persisted, preventing her from competing at maximal capacity.

After the Olympics, she continued to experience a viselike squeezing of her proximal thigh that caused a throbbing pain at the end of a race. The patient was unable to travel to Europe to run in the late summer competitions. She discontinued racing for the next several months, and by midautumn her symptoms had resolved except for occasional left buttock pain with prolonged sitting. During this period, she became pregnant but continued to stay in shape with gentle running, aerobics, and light weight lifting. The following autumn, she started running again without significant pain; however, as her training intensified, she noted increasing pain in the right buttock and decided to seek a second opinion at our clinic. Her symptoms were present even at rest or sitting on a hard surface and most pronounced with track work and faster speeds. She also noted an associated lack of power and drive in her legs. She did not have any current low-back pain, numbness, or tingling in the lower extremities or any bowel or bladder symptoms.

Previous injuries included plantar fasciitis 8 years earlier and bilateral tibial stress fractures in high school. Her medical history was also significant for asthma, iron-deficiency anemia, and frequent epistaxis secondary to Osler-Weber-Rendu disease, an autosomal dominant disorder characterized by telangiectases of the skin and mucous membranes and associated bleeding. Current medications included theophylline, astemizole, nedocromil sodium, and ferrous sulfate supplements.

**Exam.** Physical examination revealed supple and full range of motion of the lumbosacral spine and hips. Her posture was notable for increased lumbar lordosis and anterior pelvic tilt, which was greater on the right side than on the left. The bent-knee stretch test recreated her buttock pain on the right. The slump test also reproduced her buttock pain and sciatica down her posterior thigh. The same maneuvers on the left side were negative. Her neurologic exam was otherwise within normal limits. Her leg lengths were symmetric. Palpation revealed mild tenderness over the right sacroiliac joint and sciatic notch and exquisite tenderness over the right ischial tuberosity.

**Tests.** Previous lumbar spine radiographs, including anteroposterior and flexion-extension views, were unremarkable. An earlier magnetic resonance image (MRI) of the lumbar spine was notable only for a small central disk bulge at L4-5. A new MRI of the pelvis was ordered and revealed focal high-signal intensity in the right ischial tuberosity, indicating bone marrow edema. It also showed associated thickening and surrounding soft-tissue edema of the proximal hamstring at its attachment.

**Diagnosis.** Based on these findings, the final diagnosis was high hamstring tendinopathy.

**Treatment.** Physical therapy modalities, such as ultrasound and iontophoresis, were ineffective in relieving her pain. She was then treated with a therapeutic corticosteroid injection performed with ultrasound guidance. A combination of local anesthetic and corticosteroid was injected using a 22-gauge, 3-in. spinal needle just distal to the ischial attachment of the affected hamstring muscle. After this injection, she no longer had pain at rest. She then began a progressive hamstring flexibility and soft-tissue mobilization program. Muscle energy techniques were also used to normalize her right anterior innominate hip rotation. In the following 3 months, she progressed through an eccentric hamstring and core-strengthening program. Three months after starting treatment, she gradually resumed her running program, and 6 months after diagnosis, she was able to return to elite racing without pain.

#### Basic Hamstring Anatomy

The hamstrings consist of three muscles: the semitendinosus, the semimembranosus, and the biceps femoris (long and short heads).<sup>2</sup> All three muscles, except for the short head of the biceps femoris, originate from the ischial tuberosity as an incompletely separated tendinous mass (figure 1). The separate muscles become distinguishable 5 to 10 cm from the tuberosity, with the semimembranosus splitting off first and coursing along the medial side of the femur. It has multiple insertions at the posteromedial corner of the knee, with its primary attachment at the posterior tubercle of the medial femoral condyle.<sup>3</sup>

**View:** [\(Figure 1\)](#) - Anatomic drawing of the posterior thigh shows the origins (A) and major muscles (B) of the hamstrings.

The semitendinosus, identified by its long, fibrous distal tendon, originates from two distinct points.<sup>2,3</sup> The first origin is the inferomedial aspect of the upper portion of the ischial tuberosity. It shares this origin with the long head of the biceps femoris. The second origin is from a combined aponeurosis of the semitendinosus and long head of the biceps femoris distal to the ischial tuberosity. The distal tendon then passes over the tibial collateral ligament to form the pes anserinus, inserting behind the attachment of the sartorius and below the gracilis.

The lateral aspect of the hamstring is the biceps femoris muscle. Like its brachial counterpart, the biceps femoris has a long and a short head. The long head has a two-component origin: the inferomedial ischial tuberosity and the sacrotuberous ligament.<sup>2,3</sup> The origin of the short head has three components: the lateral tip of the linea aspera, the lateral supracondylar line, and the lateral intermuscular septum. The long head fibers pass laterally, anterior to the sciatic nerve, and intertwine with the short-head muscle belly to form a tendon that inserts onto the fibular head and lateral tibial condyle. The short head has multiple insertions that intertwine with the tendon of the long head, the posterolateral capsule, fibular head, proximal lateral tibia, and iliotibial tract.

The semimembranosus, semitendinosus, and long head of the biceps are innervated by the tibial branch of the sciatic nerve. The short head of the biceps femoris is innervated by the peroneal branch from the same root levels, L5 to S2.

Histology of the hamstring musculature reveals a possible contributing factor for injury while running.<sup>4</sup> Compared with other muscles in the lower extremity, the hamstrings have a higher proportion of type 2 muscle fibers, suggesting that the muscle can generate high intrinsic tension force. In addition, running increases the time that the muscle group is under maximal stretch (ie, hip flexed, knee extended). These two forces can place high demands on the hamstrings and their tendon attachments, especially during eccentric contractions.<sup>5</sup>

#### Fundamental Biomechanics

The hamstrings have mechanical effects at both the hip and knee.<sup>3</sup> All three muscles (except for the short head of the biceps) work with the posterior adductor magnus and the gluteus maximus to extend the hip. The hamstrings also flex the knee and weakly adduct the hip. The long head of the biceps femoris aids in lateral rotation of the thigh and leg; the more medial semimembranosus and semitendinosus muscles assist with medial rotation of the thigh and leg. When the hamstrings contract, their forces are exerted at both joints simultaneously; functionally, however, they can actively mobilize only one of the two joints at the same time.

During running, the hamstrings have three main functions.<sup>2,3,6</sup> First, they decelerate knee extension at the end of the forward swing phase of the gait cycle. Through an eccentric contraction, the hamstrings decelerate the forward momentum (ie, leg swing) at approximately 30° short of full knee extension. This action helps provide dynamic stabilization to the weight-bearing knee. Second, at foot strike, the hamstrings elongate to facilitate hip extension through an eccentric contraction, thus further stabilizing the leg for weight bearing. Third, the hamstrings assist the gastrocnemius in paradoxically extending the knee during the takeoff phase of the running cycle.

#### Primary Patient Workup

Initial evaluation of a patient who has a suspected proximal hamstring tendinopathy includes a focused history. Most patients with this injury will be recreational or competitive running athletes. They typically report vague, deep buttock pain caused by running. In severe cases, this pain will be present when the patient sits or drives a car.<sup>1</sup>

We use the following physical exam tests to assess soft-tissue dysfunction, flexibility, neural tension, and strength. The test results confirm the diagnosis and guide treatment.

**Soft-tissue dysfunction.** Patients are assessed for tenderness to palpation around the ischial tuberosity and proximal hamstring tendon and for signs of thickening or tightness of the proximal hamstring tendon.

**Hamstring flexibility.** Proximal hamstring tightness is assessed with the bent-knee stretch test (figure 2). A side-to-side comparison typically demonstrates tightness and recreates pain at the hamstring origin on the symptomatic side.

**View: (Figure 2) - The bent-knee stretch test for proximal hamstring tightness is performed with the patient supine.**

**Neural tension.** This is assessed with a slump test (figure 3). Signs of adverse neural tension range from tightness and pain in the buttock or hamstring to classic radicular pain in the leg caused by sciatic nerve entrapment.<sup>1,7</sup>

**View: (Figure 3) - The slump test is performed with the patient seated on the examination table with his or her arms behind the back.**

**Strength.** The supine plank test (figure 4) assesses dynamic strength. The test is performed with the pelvis elevated while the patient is resting on his or her elbows and heels.

**View: (Figure 4) - The supine plank test is used to assess strength.**

An acute strain would be indicated by positive findings on the three above noted tests: tenderness to palpation, a positive bent-knee stretch test (with or without adverse neural tension), and a positive supine plank test. This could also indicate aggravation of an underlying chronic injury. The absence of significant palpable tenderness indicates a more subacute injury with probable underlying fibrosis and scarring.

Narrowing the Differential Diagnosis

When a running athlete presents with buttock or posterior thigh pain, the differential diagnosis can be very challenging, even for the most astute clinician (table 1).

**View: (Table 1) - Differential Diagnosis of Buttock and Posterior Thigh Pain**

A thorough history and examination, complemented by the appropriate diagnostic studies, can help guide the clinician to an accurate diagnosis.

The first step is to determine whether the pain is local or referred.<sup>7</sup> Diffuse pain that varies in location is indicative of referred pain. Buttock pain associated with low-back pain suggests referral from the lumbar spine; however, as in our illustrative case, sometimes the cause of pain can be both local and referred. Pain in the lumbar spine can refer from the disk, zygapophyseal joints, muscles, or ligaments.

More localized, fairly constant pain is more likely to stem from pathology in the buttock itself. Pain localized to the ischial tuberosity is consistent with proximal hamstring tendinopathy, but it could also represent ischiogluteal bursitis or, in children, an apophysitis or avulsion.<sup>3,7</sup> If the

pain is more proximal (in the upper gluteal region and medial to the greater trochanter), the piriformis muscle may be the pain generator. Pain from the piriformis may be myofascial or from muscle strain. Local and referred pain from pressure on the sciatic nerve caused by its aberrant course through the piriformis muscle is commonly called piriformis syndrome, although piriformis impingement may be a more accurate term.<sup>7</sup>

Pain directly over the sacrum or along the sacroiliac joint may derive from sacroiliac joint malalignment, a pelvic stress fracture (typically the sacrum or, less commonly, the ilium), or inflammation of the sacroiliac joint, often associated with spondyloarthropathy.

Less common causes of diffuse exercise-induced buttock or posterior thigh pain include chronic compartment syndrome of the posterior thigh, endofibrosis of the external iliac artery, or a pseudoaneurysm of the inferior gluteal artery resulting from iatrogenic or accidental pelvis trauma.<sup>8,9</sup>

#### Essential Diagnostic Imaging

Plain radiographs may show irregularities in the ischial tuberosity, ectopic calcifications, bony avulsions, or evidence of sacroiliitis.<sup>2, 5</sup> In one study,<sup>10</sup> radionuclide bone scans were used in diagnosing an enthesopathy of the ischial tuberosity; however, we typically use MRI in persistent cases to confirm and define the extent of injury.<sup>11</sup>

Most reports regarding MRI in hamstring injuries focus on acute myotendinous strains or tears.<sup>11</sup> MRI findings for high hamstring injuries may include stress reaction or bone edema within the ischial tuberosity and direct tendon findings, including a spectrum from tendinopathy to focal partial tears (figures 5 and 6). In tendinopathy, increased signal is present on T1-weighted images without significant abnormality on fat-suppressed T2-weighted images.

**View: (Figure 5) - Axial MRIs of a 22-year-old runner who had left hamstring pain.**

**View: (Figure 6) - A coronal T2-weighted MRI with fat suppression of the same patient 5 months later.**

Focal partial tears exhibit increased MRI signal on both T1- and T2-weighted images. In more acute cases, the tendons themselves are normal, but the peritendinous soft tissues contain a small amount of surrounding edema within a few centimeters of the ischial tuberosity. This edema is most likely an inflammatory reaction, and visualization usually enhances after administration of intravenous gadolinium contrast. If inferior gluteal artery occlusion is a concern, Doppler ultrasound or magnetic resonance angiography may be helpful.<sup>8</sup>

#### Treatment Options and Rehabilitation

Fortunately, the clinician has several options for relieving high hamstring pain, preventing its recurrence, and getting the athlete back into running.

**Pain control.** Therapeutic modalities such as ice, electrical stimulation, and pulsed ultrasound are used for pain relief. As with other chronic tendinopathies,<sup>7</sup> nonsteroidal anti-inflammatory drugs (NSAIDs) are not particularly effective for high hamstring injuries, and we do not routinely prescribe them.

**Pelvic alignment.** Any signs of pelvic malalignment are corrected early in the treatment program. A common finding is anterior tilt of the innominate bones on the injured side that increases tension in the hamstrings and causes a lengthened position of their origin and insertion.

This altered pelvic position can also contribute to decreased hamstring strength. Cibulka et al<sup>12</sup> researched manipulative treatment to correct an anterior innominate position in patients who had hamstring injuries. After only one treatment, isokinetic hamstring peak torque increased by 21.5% when compared with controls. Functional improvement from this torque increase was not addressed.

**Soft-tissue mobilization.** Breaking up adhesions and scar tissue with soft-tissue mobilization can be extremely beneficial. Friction treatment with transverse glides and transverse friction are commonly recommended.<sup>7</sup> Care must be taken to avoid direct compression over the ischial tuberosity; this can aggravate the underlying bone marrow edema. Concurrent with soft-tissue mobilization, the patient may begin a gradual hamstring stretching program.

Hamstring flexibility plays a key role in effective rehabilitation. Both legs should be stretched to ensure a balanced anatomy.<sup>13, 14</sup> For optimal function, it is also important to stretch the antagonist hip-flexor muscles.<sup>7</sup> Studies<sup>5, 15</sup> support the use of frequent stretching, up to four times per day. Deep-heat ultrasound or shortwave diathermy applied before stretching can increase and sustain range-of-motion gains.<sup>16</sup> In addition, neural mobilization techniques may be emphasized as part of the stretching program, particularly in patients who exhibit signs of adverse neural tension.<sup>17</sup>

**Progressive strengthening.** A prospective study by Yamamoto<sup>18</sup> found several important variables in patients with hamstring strains versus those without. Hamstring strength per body weight was weaker, and hamstring-to-quadriceps strength ratios were lower in those with hamstring strains (0.46 in injured athletes vs 0.50 in controls,  $P < 0.05$ ). If an athlete's quadriceps or hip flexor strength was 7% to 14% greater in one leg than the other, the risk of strain increased. Based on this and other studies using isokinetic testing,<sup>2, 19</sup> a hamstring-to-quadriceps ratio of 0.5 to 0.6 is recommended to reduce the risk of hamstring injury. It is not clear if these ratios directly apply to those with high hamstring injuries, but strengthening the hamstrings is the cornerstone of our successful treatment program.

Double-leg non-weight-bearing isometric exercises are the first activities introduced (figure 7).<sup>2</sup> Single-leg closed-chain isometrics and isotonic open-chain exercises are begun when the double-leg isometric exercises can be performed without pain,<sup>20</sup> beginning with a shortened range and progressing to full motion as tolerated.

**View: (Figure 7) - Double-leg isometric bridge exercise for hamstring and gluteal rehabilitation.**

As quickly as possible, patients are introduced to an eccentric muscle strengthening program, the only proven treatment for chronic tendinopathies (figure 8). A clear relationship exists between persistent eccentric hamstring strength deficits and recurrent hamstring injuries.<sup>21</sup> Ultrasound studies show that eccentric exercises can normalize tendon thickness and tendon structure.<sup>22</sup>

**View: (Figure 8) - Ball curls- an eccentric and concentric hamstring exercise.**

Muscle adaptation to eccentric exercise increases the number of sarcomeres arranged in series in muscle; therefore, sarcomere length for a given joint angle will be less with future eccentric contractions. This increases the optimum joint angle for torque and reduces the risk of tissue damage.<sup>24</sup> This adaptation helps correct the tendency for patients to develop shorter, inflexible muscles after injury, and eccentric training has the added advantage of better preparing the

muscle for the higher-force demands of running.

Our rehabilitation protocol also emphasizes progressive core strengthening. A recent study<sup>24</sup> comparing patients in two types of hamstring rehabilitation programs supports this approach. The first group consisted of patients taught static stretches for the hamstrings, with progressive resistive exercises. Patients in the second group incorporated core stabilization exercises, defined by the authors as "muscular activity of the trunk and pelvis to maintain the spine and pelvis in a desired neutral posture or alignment." Although this study incorporated a relatively small sample size, 7 of 10 patients in the first group sustained a recurrent injury in 1 year, while only 1 of 13 was injured in the second group. Our own experience confirms that core strengthening exercises, including coactivation of the gluteal and hamstring muscles (figure 9), are an essential component of a comprehensive rehabilitation program for high hamstring injury.

**View: (Figure 9) - Prone plank with hip extension is a core-strengthening exercise.**

**Corticosteroid injection.** If physical therapy modalities, pelvic adjustments, soft-tissue mobilization, and gentle stretching are not sufficient for pain control, a corticosteroid injection into the peritendinous soft tissues is recommended. We have found these most helpful in the more acute cases when the MRI shows surrounding edema within a few centimeters of the ischial tuberosity and a relatively normal-looking tendon, although even patients who have clear signs of tendon thickening obtain modest pain relief.

Corticosteroid injections are not beneficial to long-term outcomes for tendinopathies, and therefore we never inject into the tendon itself. Under ultrasound guidance, a combination of local anesthetic and steroid is injected just distal to the ischial attachment of the affected hamstring muscle.<sup>25</sup> Ultrasound affords more precise location of the injected fluid (figure 10) and ensures that intratendinous injection is avoided.<sup>26</sup>

**View: (Figure 10) - Sagittal plane ultrasound of a 36-year-old runner who had left proximal hamstring pain.**

It is important to note that we do not perform corticosteroid injections for focal partial tendon tears. Also, the athlete should continue rehabilitation, understanding that the injection augments the therapy; it does not replace it.

**Extracorporeal shock-wave therapy (ESWT).** We have limited experience with ESWT, but it deserves mentioning, because it has been effective for other chronic tendinoses in some studies.<sup>27</sup> Future research may show ESWT beneficial for chronic hamstring tendinosis before surgery is considered for patients who have persistent pain. Biomechanical testing in animals shows significant impairment of tensile strength after shock-wave application in vitro, and, for this reason, it should be used with extreme caution.<sup>28</sup>

**Surgery.** The small subset of patients who have persistent pain at the hamstring origin, with or without associated neuropathic pain, are referred for surgery. The surgical technique involves dividing the taut, tendinous structures of the hamstring muscles near the origin (ie, over the sciatic nerve) without loosening the muscle from the ischial tuberosity, thereby relieving tension and freeing the nerve.<sup>1</sup> Histologic specimens from surgical cases show evidence of dense fibrosis and, in some cases, hyaline degeneration at the attachment of the hamstring to the ischial tuberosity.<sup>1</sup> Within the fibrosis, an entrapped branch of the sciatic nerve can cause radicular-type neuropathic pain in the involved extremity.

## Return to Running

A graduated return to activity will depend on a host of factors, including the severity and chronicity of the condition and the premorbid functional level of the athlete. Most athletes make a full recovery within 3 months of diagnosis. Early in rehabilitation, athletes should be encouraged to maintain aerobic fitness using an upper-body ergometer or swimming with a buoy between the thighs and pulling with the arms only. When normal pain-free range of motion is restored (as evident by a negative bent-knee stretch test), stationary biking, elliptical machine work, and pool running can be incorporated into the recovery program.

The preferred training method—pool running—is a nonimpact exercise that most closely resembles muscle recruitment patterns of land-based running.<sup>29</sup> A flotation device around the waist will assist with buoyancy and proper technique. Maintaining quick turnover (ie, rapid gait cycling) and coordinating movements between the arms and legs is recommended. If patients are pain-free when the supine plank strength test is performed, they can start a return-to-running program as outlined in table 2.

**View: [\(Table 2\)](#) - Return to Running After High Hamstring Tendinopathy**

### Running Recap

High hamstring tendinopathy is a relatively uncommon overuse injury seen in athletes who typically experience deep buttock pain brought on with distance running, especially at faster speeds. The differential diagnosis can be vast, and a detailed physical examination is necessary to rule out other potential causes of buttock or thigh pain. Once the diagnosis is confirmed, an aggressive rehabilitation program is initiated, including soft-tissue mobilization, frequent stretching, and a progressive eccentric hamstring and core-stabilization program. In recalcitrant cases, an ultrasound-guided corticosteroid injection in the tendon sheath can be helpful, and, on occasion, surgery is necessary to release scar tissue.

### Conflict of Interest Statement

**Disclosure Info:** Drs Fredericson, Moore, and Beaulieu and Mr Guillet disclose no significant relationship with any manufacturer of any commercial product mentioned in this article. No drug is mentioned in this article for an unlabeled use.

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