The Ultimate Guide to RUNNING INJURIES

The scientific signs, symptoms, and causes of the most common running injuries with research-backed treatment options and preventive exercises

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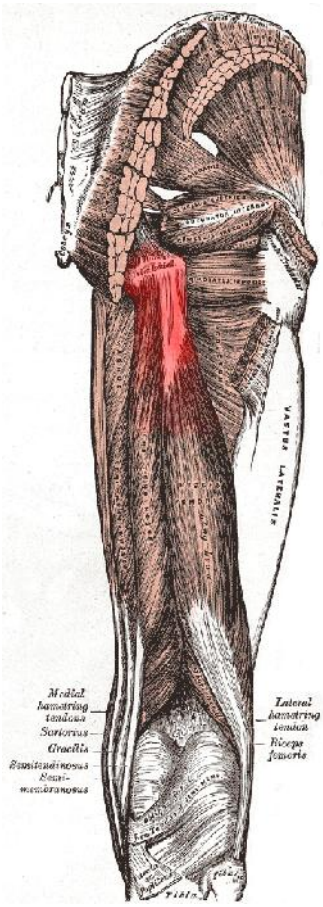
High Hamstring Tendinopathy

The hamstrings are an essential muscle group in running. They flex your knee and assist in hip extension, meaning they are active at multiple points in your gait cycle. While the most common hamstring injuries are acute or chronic muscle strains, they are also vulnerable to tendonitis at their origin, an injury **termed high hamstring tendinopathy** or **proximal hamstring tendonitis**.



While rare, this injury is difficult to treat and can become a prolonged and chronic problem. The relatively limited scientific and medical reports extant are fairly recent, and as such, there are no solid numbers on what percentage of runners come down with it.

About the injury

The hamstrings run from the top of your tibia, just behind your knee, up along the back side of your thigh and towards your pelvis. While one branch of the hamstrings attaches to the femur, the rest course up your thigh and underneath your glute muscles, attaching to the pelvis at a bony prominence called the **ischial tuberosity**. These twin "peaks" of bone are sometimes referred to as your "sitting bones," as they support much of your weight while sitting, especially on hard surfaces. The junction between the tendons of the hamstrings and the ischial tuberosity is the area affected by high hamstring tendinopathy.

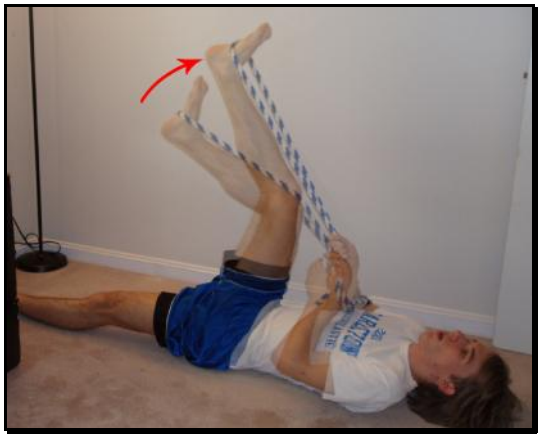
High hamstring tendinopathy feels like a vague, aching soreness high up on your hamstrings and deep in your buttock. There will be pain when you run, especially when accelerating and when maintaining a fast pace. Sometimes the sciatic nerve, which passes very close to the ischial tuberosity, can become irritated as well, resulting in pain that radiates down the back of your thigh. In addition to pain while running, you may feel irritation at the ischial tuberosity while sitting on hard surfaces. It also may hurt to press directly on the ischial tuberosity.

A host of other injuries can cause deep buttock pain, including piriformis syndrome, muscle strains, a sacral stress fracture, or pain radiating from low back injuries, so it's important to get an accurate diagnosis.

Tests to diagnose

A review study published in January of 2012 outlined three physical tests for high hamstring tendinopathy.[1] The first is a simple standing hamstring stretch, where you rest your foot on a knee- to waist-high support and stretch your hamstrings.

The second is an assisted hamstring stretch, done while you are lying on your back. With your hip and knee flexed, an assistant slowly straightens your knee to stretch the hamstring. It may be possible to replicate this test without an assistant by using a rope or a belt, as pictured below.



The third test is similar to the second, but this time, the knee is rapidly straightened by an assistant. High hamstring or buttock pain with any of these three tests is indicative of high hamstring tendinopathy. While these tests were fairly accurate, correctly identifying between 76 and 89 percent of the injured runners, none were perfect, highlighting the usefulness of high-tech imaging to accurately diagnose or rule out high hamstring tendinopathy.

MRIs can be very fruitful in evaluating hamstring injuries, as described by Marc Sherry of the University of Wisconsin in a recent review article.[2] An MRI can spot tendon thickening, tearing, inflammation, and swelling in the bone at the ischial tuberosity. Ultrasound can also used, but unlike an MRI, it can't visualize bone marrow edema.

Research backed treatment options

In one of the few comprehensive articles on treatment for high hamstring tendinopathy, Michael Frederickson, William Moore, Marc Guillet, and Christopher Beaulieu at Stanford University provide a very insightful outline of treatments their group has found helpful for high hamstring injuries in runners.[3]

After the diagnosis has been confirmed with a physical examination and MRI scan, the injured patient is evaluated for core strength, hamstring flexibility, and pelvic stability. Frederickson et al. recommend that any pelvic tilt be corrected (presumably by manual or chiropractic manipulation, though the article does not specify how), as it can increase hamstring tension. They also endorse soft-tissue work to break down scar tissue along the proximal hamstring tendon, though the authors caution that direct compression of the ischial tuberosity should be avoided. Other case studies have also supported the usefulness of soft tissue manipulation, including techniques like ART and Graston, for the treatment of high hamstring tendinopathy.[3] Gentle stretching of both hamstrings several times a day is also encouraged. But as Frederickson et al. point out, the core of their rehabilitation program is eccentric strengthening of the hamstrings.

Like the patellar and Achilles tendons, the tendon at the origin of the hamstrings is thick, fibrous, and has a poor blood supply, which makes healing difficult. Additionally, much like in these two more common tendon injuries, tendonitis of the high hamstrings appears to be a degenerative process, not an inflammatory one.[4] This means that the fibers of the tendon are becoming frayed, damaged, and disordered. However, because we know that both Achilles tendonitis and patellar tendonitis can be effectively treated with eccentric strength exercises, it is quite logical to base a rehab program for high hamstring tendinopathy around eccentric exercise as well.

The strength rehabilitation program begins with simple isometric hamstring and glute exercises like glute bridges. As soon as these are tolerated, Frederickson et al. recommend progressing towards eccentric exercises as soon as the introductory exercises can be done without pain. A standing "hamstring catch" exercise can serve as a good introductory eccentric exercise, and Frederickson et al. endorse Swiss ball curls as ideal for development of both eccentric and concentric strength. These Swiss ball

curls can be progressed as tolerated, moving from short range of motion to full range of motion and eventually, single-legged Swiss ball curls.

Frederickson et al. also emphasize the importance of core strength in hamstring injury rehabilitation, citing another study which found that core strengthening reduced the risk of recurrent hamstring strains. It's possible that a strong abdomen and hip musculature can stabilize the pelvis, taking strain off the hamstring. Frederickson's paper focuses on the use of plank exercises, particularly with leg lifts incorporated to encourage coactivation of the glute and hamstring muscles, as a key component of recovery.

Other possible treatment options

Other options discussed in the Fredericson et al. paper include corticosteroid injections and extracorporeal shockwave therapy. Both of these treatments have the potential to weaken the tendon, so they are reserved as ancillary treatments, not a sole basis for recovery.

Corticosteroid injections are better understood, and while injections directly into the tendon itself can be quite harmful, Fredericson et al. write that, by using ultrasound imaging to guide the injection needle, the anti-inflammatory drug can be delivered to the irritated tissue surrounding the tendon without penetrating or damaging the tendon itself. They also found that patients whose MRIs exhibited more swelling around the ischial tuberosity and less thickening of the tendon got more relief from a cortisone injection than patients with more pronounced tendon thickening.

Extracorporeal shockwave therapy is mentioned briefly, as it has been found to be effective in other types of chronic tendon injuries in athletes,[5] though Fredericson et al. caution that they have little experience using it for high hamstring tendonopathy and that animal studies have shown that it results in a drop in tendon strength (at least in the short term).

Finally, in a small number of cases, surgery is necessary to relieve tension on the sciatic nerve and divide up the fibrous and damaged tendon near the ischial tuberosity. The good news is that, according to a 2009 study by Lasse Lempainen and coworkers in Finland, a high percentage of athletes eventually return to the same level of sport after being referred for high hamstring tendinopathy surgery.[6] Eighty of the 90 patients referred in Lempainen's study made a return to the same level of sport, with 62 of them having "excellent" results. While this is encouraging, the mean recovery time of five months (and ranging from two to twelve) is sobering and serves as a reminder that few

surgeries for a running injury are ever really "minor" when it comes to time off from running.

High hamstring tendinopathy is a persistent and difficult injury to overcome. Additionally, due to its relative rarity (especially outside of running) and the paucity of good review studies on potential treatments, the evidence for solid treatment protocols is still lacking.

On the bright side, however, since it's known to be a degenerative tendon issue, the same treatment strategies that work with injuries to the Achilles and patellar tendons should also be effective with high hamstring tendinopathy.

As Frederickson's article outlines, a progressive strength program to strengthen the core, improve glute strength, and promote healing in the proximal hamstring tendon through eccentric exercises should be at the heart of any rehabilitation program. Due to the similarity of some of this injury's symptoms with other hip injuries, it's important to get a proper diagnosis; this will likely entail a physical examination and an MRI.

Additionally, because of the individual nature of this injury, it's recommended that you find a good orthopedist and physical therapist to supervise your rehabilitation and advise you on your return to running.

Outline of Treatment

Conservative treatments:

Because of the recalcitrant nature of high hamstring tendinopathy, exercises for rehabilitation need to be eased into. Unlike the eccentric programs for Achilles or patellar tendonitis, you shouldn't jump into high-load exercises right off the bat.

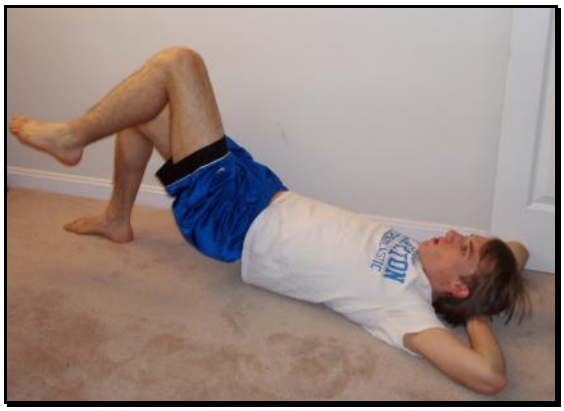
According to the protocol outlined in Fredericson et al., the following exercises should be incorporated into your rehab protocol in order, but *only* after you have been able to do the previous one without pain. Unfortunately, the Fredericson paper does not describe how many sets and repetitions of each exercise to do, but a Runner's World article on the same injury recommends several similar exercises and advocates progressing to 3-4 sets of 10-15 repetitions of each exercise once per day.[7]

Double leg glute bridge

Gentle hamstring stretching, 3-4 times a day

Front plank

Double leg glute bridge with leg lifts



Front plank with leg lifts

Standing hamstring "catch"

Swiss ball curls and Swiss ball curls with one leg




Aggressive treatments

1. See a physical therapist or chiropractor for manual therapy, massage, ART, or Graston Technique to break down scar tissue and adhesions in the high hamstring area. Make sure the practitioner focuses on the muscle and tendon tissue and avoids the ischial tuberosity—you don't need any additional irritation there.

2. Talk with an orthopedist about a corticosteroid injection, preferably guided by diagnostic ultrasound imaging. According to Fredericson et al., this can be especially helpful in cases where an MRI shows significant swelling near the ischial tuberosity.

3. Consider talking with your doctor about the risks and benefits of extracorporeal shockwave therapy. While it's unproven in high hamstring tendinopathy, it has shown some success with chronic tendon issues elsewhere in the body.

4. If repeated attempts at conservative treatments fail, talk with a trusted orthopedist about surgical treatment.

Return to running

High hamstring tendinopathy is reported to take a long time to recover from. Of the few case studies on runners with high hamstring tendinopathy, all report recovery times on the order of 8-12 weeks,[8] a timescale echoed by Fredericson et al.

Cross training activities should not stress the lower legs until the bent-knee stretch test can be done without pain; at this point, activities like cycling and pool running can be incorporated into your routine.

Once you can perform a back plank with leg lifts pain-free on both sides (pictured below) and have normal range of motion, you can being the gradual return-to-running program outlined here:

Week 1	Walk 5min / jog 1min, build to 5 sets on alternating days (ex. 2x5min/1min, off, 3x5min/1min, off, etc.)
Week 2	If no pain, walk 5min / jog 5min, build to 5 sets on alternating days
Week 3	If no pain, advance to 20min jog, no more than 5 days per week
Week 4	If no pain, advance to 20min run at normal training pace, no more than 5 days per week
Weeks 5-8	If no pain, gradually increase running speed, volume, and acceleration as tolerated

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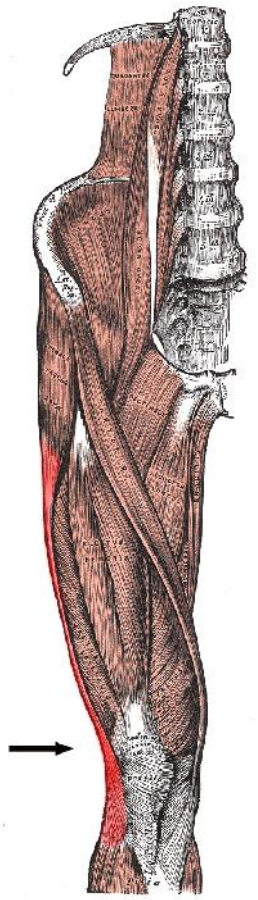
Iliotibial Band Syndrome/ITBS

About the injury

The iliotibial band, or IT band, is a long "band" of tissue that runs from the top of the hips down the outside of the thigh, crossing the outside of the knee and inserting at the very top of the tibia. While many people envision the IT band as an independent structure that can freely slide forwards and backwards relative to the rest of the leg, in reality, it is nothing more than a thickened strip of fascia, the connective tissue that encapsulates the muscles of the body. The IT band serves as a connection between many of the major hip muscles and the knee. Its main function during running seems to be stabilizing the knee during footstrike.



Iliotibial band syndrome, or ITBS, is an injury to the IT band. It most commonly occurs on the outside of the knee or just above it, though it is not unheard of to get pain further up the IT band, even as far as the top of the femur.

ITBS accounts for somewhere between 8 and 10% of all injuries,[1] and doesn't seem to discriminate: both recreational runners and elites suffer from this injury. IT band syndrome usually hurts after a set distance into a run—you'll feel okay for a mile or two, but the outside of your knee will start to ache, progressing from a dull stiffness to a sharp or burning pain. It is typically worse when going down hills, and you may sometimes feel pain when sitting with your leg bent for a long time. Any activity which brings the knee into 20-30 degrees of flexion can aggravate the IT band, as this is when the band itself gets squeezed against the femur the most.

Causes, what makes it worse, what's going on

Just before the IT band crosses the knee, it runs on top of a large knob on the femur called the lateral epicondyle. The prevailing opinion for a long time was that the IT band slides back and forth across this bony knob, leading to the term "IT band friction syndrome." However, recent anatomic studies have shown that the cause is more likely compression—the IT band is squeezed against the bone, irritating an area rich in blood vessels and nerve endings between the two structures.[2]

While factors like old shoes, running on cambered road surfaces, and tight turns on indoor tracks have all been proposed as risk factors for ITBS, none of these have much scientific evidence to back them up.

However, a host of studies have connected hip abductor and external rotator muscle weakness with ITBS. In a healthy and strong runner, these muscle groups keep the hip abducted and the knee externally rotated, which limits the strain on the IT band.[3, 4, 5] But when these muscles are weakened, the hip adducts and the knee internally rotates after impact with the ground, crushing the IT band and the underlying sensitive tissue against the lateral femoral epicondyle. Current theories hold that the nerve endings sandwiched between the IT band and the femur are supposed to send signals to the glute muscles to fire when the IT band is being compressed—of course, when these muscles are weak or dysfunctional, this protection mechanism fails. Instead of the gluteus medius and the other main hip abductors firing, the TFL (tensor fascia lata) muscle fires, which puts even *more* strain on the IT band. [2]

Research backed treatment options

IT band syndrome is a classic biomechanical problem. Muscular weakness and dysfunction causes a predictable and repeatable change in running mechanics, increasing strain on the IT band and causing injury. So, while the painful area is the outside of the knee, the real problem lies further up the leg. While icing, stretching, and foam rolling all have their role, a biomechanical problem ultimately needs a biomechanical solution. This is where hip strengthening exercises come in.

The best current research-approved protocol for ITBS was described in a 2000 paper by Michael Fredericson at Stanford University.[4] His rather simple program consists of two stretches and two strength exercises. The stretches are performed **three times per day** holding the stretch for **15 seconds each on both sides**. The strength exercises start with **one set of 15 repeats** every day, building up to **three sets of 30** over time. The entire program lasts six weeks. Fredericson's athletes avoided running during this six-week protocol, and 92% recovered completely.

The Fredericson protocol:

1. Lying rope hip stretch

2. Standing hip crossover stretch

3. Lying hip abduction

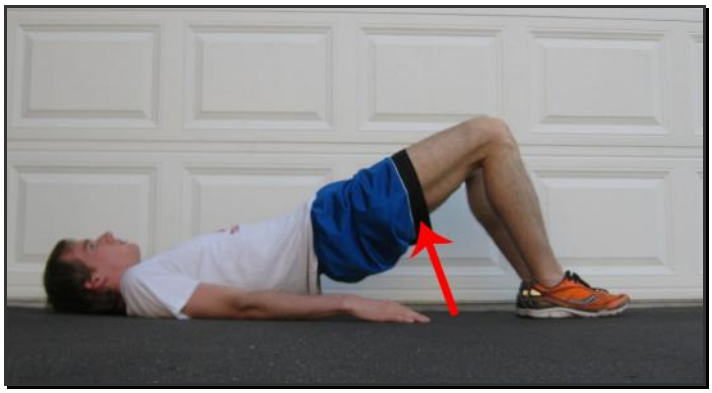
4. Standing hip hike

Other possible treatment options

While Fredericson's results were impressive, his study had some flaws. For one, it had no control group, so it's unclear how much of the improvement was from the exercises and how much was from the time off. Additionally, his protocol lacks any exercises that strengthen the external rotators. I recommend adding the following exercises to address external rotator and abductor strength at the same time, as well as adding some isometric strength, which is more similar to how these muscles function while running:

1. Clamshells

2. Glute bridge



The "up" position is held for 5 seconds

3. Wall isometric

The inside leg is pushed into the wall for a 5-second hold.

With regards to stretching, the IT band itself is not particularly amenable to it, for two reasons. First, it is not a stretchy tissue. Its stiffness is more in line with a car tire than a rubber band.[6] And second, stretches that purportedly target the IT band don't actually stretch it very much, since it attaches to the femur at several places.[7] Instead, research suggests that you should target the muscles that *attach to* the IT band: the gluteus maximus and the TFL. Fredericson's two stretches accomplish this very well.

Using a **foam roller** to loosen up soft tissue around the IT band is a great idea, but actually rolling over the painful area should be avoided. Remember, IT band pain stems from irritating the highly sensitive area between the bony knob on the femur and the IT band, so you don't want to further aggravate this spot!

Some people find that a particular shoe style aggravates their IT band, but there's no scientific evidence that points towards any kind of shoe or custom insert causing or curing IT band problems. All the evidence thus far points to the root cause being at the hips, not the feet, so your number one priority should be to strengthen your abductors and external rotators.

Outline of treatment

Conservative treatments

These are methods that are fairly simple, inexpensive, and can be done on your own at home.

Hip strengthening: Fredericson protocol + added exercises:

Fredericson protocol:

1. Lying hip stretch with rope, 3x/day, 15sec hold each side
2. Standing crossover stretch, 3x/day, 15sec hold each side
3. Lying hip abduction, start with 1x15 once per day, build to 3x30 once per day
4. Standing hip hike, 1x15 → 3x30 once per day

Additional exercises:

5. Clamshell exercise, 1x15→ 3x30 once per day
6. Glute bridge with 5sec hold, 1x15 → 2x20
7. Wall isometric with 5sec hold, 1x15 → 2x20

Additional therapies:

8. Foam rolling of the quads, hamstrings, glutes, and upper hip area 1-2x per day
9. Icing with ice cup: 10-12 minutes, 2-5 times per day

Aggressive treatments

These are treatments with more cost and less certainty about outcomes, but may prove useful in recalcitrant cases.

10. Active Release Technique (ART) and/or Graston technique. These are soft tissue manipulation therapies that are intended to break down scar tissue in chronically injured areas. While there is little to no science backing their efficacy, some runners have found relief from ART or Graston. Most practitioners are chiropractors, so this treatment may or may not be covered by insurance. It should not be used on acute cases of ITBS, however.

Return to running:

Since IT band syndrome is the result of a biomechanical problem, your ability to return to running will be determined by your progress in hip strength. In the initial stages of the injury, you will need anywhere from a few days to a few weeks of time off for the initial inflammation on the outside of the knee to calm down. Icing often can speed this along. Once the initial irritation is gone, you will probably find that your IT band still gets irritated after a few miles of running if you haven't worked on your hip strength. In my experience, it takes about a month of daily hip strength exercises to completely recover, though you may be able to run during this time period. You just need to keep your runs short enough so that they do not aggravate your IT band anew. If all else fails, you may need an extended break from running to rebuild your strength like the subjects in Fredericson's study.

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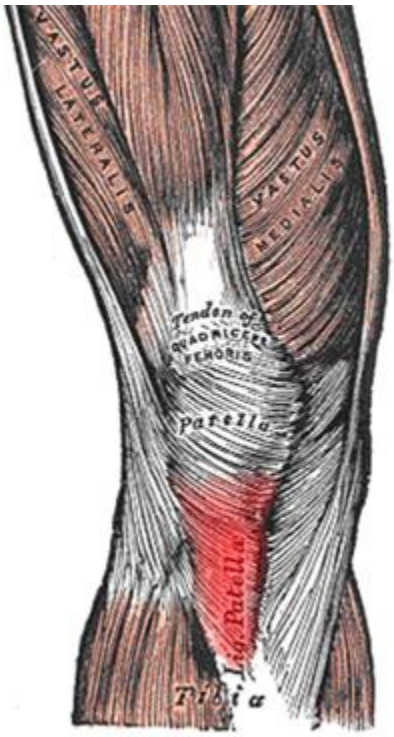
Patellar Tendonitis



The patellar tendon is a short but very wide tendon that runs from your patella (kneecap) to the top of your tibia. The reason you have a kneecap in the first place is to generate a bigger mechanical advantage at the knee—this allows your quadriceps to create strong forces at the knee, which are important in any sport with running or jumping elements.

However, the result of this is that the patellar tendon has to absorb a lot of this loading, and as a result, it's prone to injury in runners and jumpers; **one study found that patella tendonitis accounts for just under 5% of all running injuries.**1 Unlike many common running ailments, patellar tendonitis is somewhat more common in men than in women.

Patellar tendonitis usually begins with a stiff feeling in the patellar tendon, especially when running downhill or descending stairs. Like most tendon injuries, it may go away once you get warmed up, but as the injury worsens, it will remain painful for the duration of your workout.

It is also important to distinguish patellar tendonitis from patellofemoral pain syndrome: patellar tendonitis does not hurt along the top or the side of the kneecap, and isn't usually sensitive to the touch.

Epidemiology – Causes of Patella Tendonitis, what makes it worse, what's going on

Because the patellar tendon absorbs so much force, the long strands of connective tissue that make up the tendon can become injured. As with Achilles tendonitis, the true problem seems to be not so much the inflammation, but the damaged and degraded tendon structure that results from chronic stress on the patellar tendon. Unfortunately, this can result in patellar tendonitis becoming a chronic issue that persists for months.

- Poor hamstring and quadriceps flexibility have both been connected with an increased risk for patellar tendonitis.
- Moreover, poor explosive leg strength may be related as well.
- Additionally, weak thigh muscles might be unable to adequately slow down your descent during impact, subjecting your knee to greater loads.

Conceptually, this makes sense, as tighter upper leg muscles would increase the tension on the knee, making it more difficult to flex and extend the joint.

Research backed treatment options for Patella Tendonitis

While the causes behind patellar tendonitis are not as well-understood as other injuries, there is fortunately very strong evidence for a treatment protocol.

The treatment of choice, a program of eccentric decline squats, was inspired by the success of eccentric heel drops in treating Achilles tendonitis.

Hypothesizing that eccentric activity encouraged the body to gradually replace and realign the damaged tendon fibers, researchers turned to a program of one-legged squats to eccentrically load the patellar tendon.4 However, they found that they were not as effective as expected, since the calf instinctively assists the knee when squatting, which takes some load off the front of the knee and the patellar tendon. To work around this, researchers devised the eccentric decline squat, 5 which is done on a downward-slanted surface to unload the calf.6 **Interestingly, this may also be why running with patellar tendonitis hurts more on downhills!**

In one small but very rigorous pilot study, Purdam et al. demonstrated that an eccentric decline squat protocol of three sets of 15 squats twice a day was vastly superior to an identical eccentric squat program done on a flat surface.

Like the eccentric heel drop protocol for Achilles tendonitis, subjects in the studies on

eccentric decline squats were encouraged to continue doing the exercises even with moderate pain (though stopping if the pain becomes extreme), and to add weight with dumbbells or weights in a backpack once they could do the basic 3×15 protocol pain-free.

Unfortunately, eccentric decline squats do require some specialized equipment; namely, a slanted board at about 25° (which corresponds to a rise of one foot per two feet of horizontal distance).

If you have a calf stretching board on hand, it will work perfectly. If you're handy with tools, they aren't too difficult to build. But even if you aren't, you can usually make do by leaning a wooden plank against the bottom step on a staircase or up against a curb (as pictured above).

To do one eccentric decline squat, stand on the decline board with your foot pointing "downhill." While balancing on your injured leg, squat downward slowly to about 60° of knee flexion. Then use your good leg to rise back up to the starting position. Do not use the injured leg to return to the top!

Again, moderate pain with this exercise is okay. Just stop if it becomes excruciating. Once you can do the exercise pain free, you should add weight with a loaded backpack, again continuing into moderate pain.

Other possible treatment options

- In addition to the eccentric decline squat protocol, it makes a lot of sense to take steps to address potential tightness in your hamstrings and quads. Stretching them a few times a day is a very good idea, as is using a foam roller to loosen them up. You may find that a harder foam roller or even a 3" diameter plastic PVC pipe works better on your hamstrings, especially if you have muscular thighs.

- It's also possible that a shoe with a lower heel-to-toe drop may load your patellar tendon less, since running in a standard shoe with a 12mm heel-to-toe drop is similar to running on a downhill. If you want to experiment with lower-drop shoes, be aware that the load that's transferred from your knee will be reallocated to your forefoot, ankle, and Achilles, so exercise caution here.

- Some very new pilot studies have suggested that platelet-rich plasma injections, a therapy which involves injecting a concentrated form of platelets found in your own blood, and extracorporeal shockwave therapy, a souped-up version of ultrasound, may be able to stimulate healing as well.8, 9 As the patellar tendon has poor blood supply, and hence a reduced capacity to repair itself, the idea behind platelet-rich plasma (or PRP) injections is that growth factors in the platelets accelerate healing.

- Likewise, extracorporeal shockwave therapy (or ESWT) aims to selectively break down tissue to accelerate healing. While evidence to date suggests that these are a fairly safe and effective treatment for very stubborn cases of patellar tendonitis, there's no data on long-term effects, and you're unlikely to have it covered by insurance. Consider talking to your doctor about a PRP injection or ESWT if you've had little or no success with conservative treatment for several months.

Outline of treatment options

Conservative treatments

These are cheap, easy to perform treatments that you can do it home in your own time. You should try to do as many of these as possible each day.

1. Eccentric single leg decline squats—3 sets of 15 reps, twice per day. It's okay if the decline squats hurt somewhat, but the pain shouldn't be excruciating. Once you can do all three sets without pain, add weight using a weighted backpack. Return the starting position using your good leg. You'll need to find, construct, or improvise a decline ramp

to do these on, but it's well worth it, as decline squats are much more effective than squats on flat ground.

2. Icing after each run.

3. Gently stretch your hamstrings and quads a few times a day.

4. Massage your hamstrings and quads with a foam roller, PVC pipe, or The Stick

Aggressive treatments

These treatments are a little more expensive or time consuming and are only suggested for if you suffer from chronic patellar tendonitis pain and the conservative treatments are not working for you.

1. Consider running in a lower-heeled shoe to transfer some stress from your knee to your foot, calf, and ankle. Exercise caution if you have had foot or calf injuries in the past.

2. Ask an orthopedist about platelet-rich plasma (PRP) injections or extracorporeal shockwave therapy (ESWT).

Return to Running

The standard program of eccentric decline squats calls for 12 weeks of eccentric decline squats before returning to sporting activity, but one encouraging study of volleyball players who trained and competed while doing the rehab program and still had good success rates indicates that you may be able to return to running as soon as your patellar tendon is ready to handle the loads associated with training10 (which will likely depend on the severity of your injury—a mild case may only require a couple days off, while a more severe case might call for a longer break from running). Work with your doctor or physical therapist to devise a good return-to-running program.

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Patellofemoral pain syndrome: Runner's Knee

About the injury

Patellofemoral pain syndrome, sometimes also called “runner’s knee,” is the most common of all running ailments, accounting for 16.5% of injuries according to one recent study.

It’s characterized by a dull pain that is “behind” or “around” the top of the kneecap. Typical aggravating motions include squatting, running (especially downhill), descending stairs, and prolonged sitting. If you have patellofemoral pain syndrome (PFPS), you will also likely have pain when resisting leg extension, and possibly tenderness if you push against the kneecap itself. It is important to distinguish PFPS from patellar tendonitis, which is an entirely different injury with a different treatment—patellar tendonitis manifests as pain into the tendon that connects the kneecap to your shin, the patellar tendon.

Patellofemoral pain syndrome is more common among women, though the reasons are not entirely clear. The oft-cited “Q-angle” theory, which claims that women are more prone to knee injuries because they have wider hips, has been shown to be false. Additional commonly-cited theories like leg length discrepancies and pronation are similarly unhelpful.[1]

Patellofemoral pain syndrome gets its name from the relevant anatomy around the knee: the cause of the pain is the kneecap—the patella—rubbing against the groove in the femur, where it slides back and forth when you flex and extend the knee.

Causes, what makes it worse, what's going on

Historically, research on PFPS focused on factors that affected the motion of the kneecap, particularly how the quadriceps control how the patella “tracks” in the femoral groove. Indeed, scientific research has showed that people with poor quadriceps and calf flexibility,[1] poor vertical jumping ability (which is highly dependent on your quads),[2] and weak quadriceps are all risk factors for PFPS. Blame was often ascribed to a small muscle on the outside of your thigh, called the VMO, which seems to fire differently in people with PFPS. And runners who did exercises that were designed to target the VMO often recovered! But recent research has demonstrated that these gains were probably from improvement in general quad strength, not VMO activation.[3] And unfortunately, many runners don’t find relief from doing only quad strength.

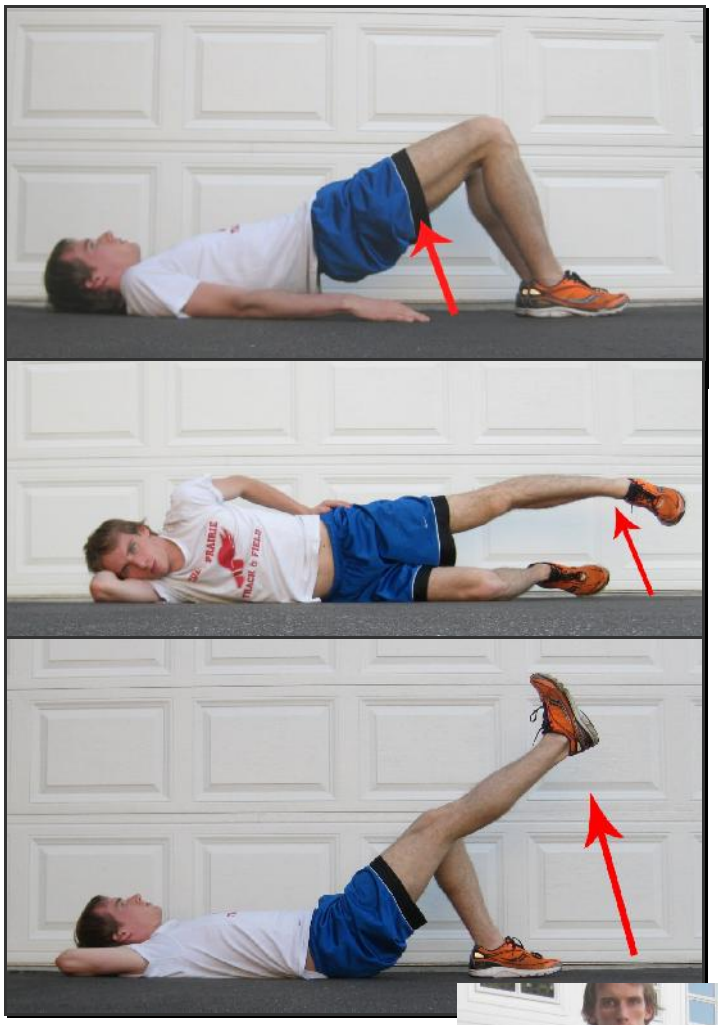
Research backed treatment options

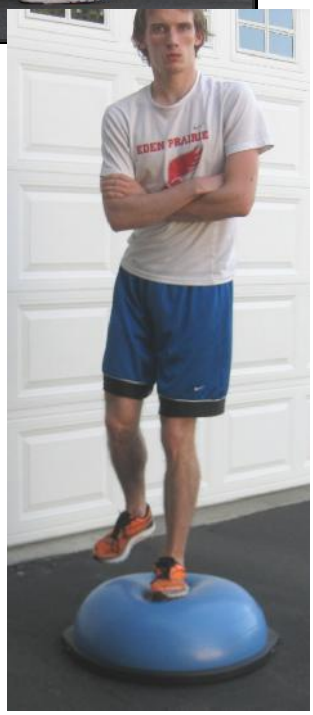
Fortunately, research in the last ten years has uncovered another mechanism that contributes to knee injuries in runners: hip mechanics. It turns out that, while it appears that the kneecap "tracks" towards the outside of your leg during squatting and running motions, it's actually the *femur* rotating underneath the kneecap![4] This surprising fact perhaps explains why many runners (particularly women) with patellofemoral pain syndrome have weak hip abductors and external rotators.[5] This seems to contribute to altered biomechanics when they run. Because of their muscular weaknesses, their knee "collapses" towards the center of their body when they run. Some work has focused on directly altering the biomechanics of runners with patellofemoral pain syndrome by using a treadmill and camera system to provide gait analysis in real-time.[6]

Unfortunately, this is not an option that's widely available to most runners. Fortunately, some preliminary research has shown very good results from hip strengthening protocols.

While there's no single "standard" rehab protocol yet that's been vetted by research, a successful program should *definitely* incorporate hip abductor, external rotator, and quadriceps strength.[7, 8]

Many programs that have produced good results also include hip flexor/extensor strength, closed-chain "functional" exercises like squats, and balance training. [9, 10] _ENREF_9





Other possible treatment options

For most runners, a dedicated strength program will be what ultimately provides relief from patellofemoral pain. But as usual, there are other treatments that can either provide temporary relief or act as a supplement to your strength training. **Stretching** and **foam rolling** can be a great adjunct to strength training and can loosen up tight calves and quads. Often, running on an injury will leave you with tight and stiff muscles, which a foam roller and some quad stretching can loosen up. Just take care not to stretch if it irritates your knee.

Applying **tape**, using either rigid athletic tape in a patellar taping, or with a flexible kinesiology tape, has been shown to provide some relief to athletes with patellofemoral pain. Some research has also indicated that knee braces (cho-pat straps, neoprene sleeves, and similar devices) may also provide some relief. It seems that the mere *presence* of the tape or the brace, which provides some tactile feedback on the skin, provides most or all of the relief, not so much the way in which it is applied or the mechanics of how it affects the knee.[11] So a loose "improper" taping helps just as much as a tight, correct taping! For this reason, I lean towards recommending flexible tapes (Kinesio tape and similar brands) as opposed to rigid tape or braces, since they stay on longer and are less likely to get irritated while out on a run. However, if you get relief from a knee brace or strap, go ahead and use it.

Custom orthotics may speed the pace of your recovery, but at least according to one study,[12] they don't appear to exert much of an influence after several weeks of rehab. This obscures the fact that many runners *have* found significant relief from custom orthotics (though others have not), so you may consider them if first-line treatments are not working for you. But given that there is little or no evidence that factors *below* the knee (i.e. the feet and ankles) play a role in the development of PFPS, custom or even over-the-counter orthotics should not be your first choice in treating patellofemoral pain syndrome.

Outline of conservative treatment:

1. Hip and quadriceps strength exercises:
    a. Abductors—lying side leg lift or band abduction
    b. External rotators—lying "clam" or band external rotation
    c. Quadriceps—straight leg lift

    No standard protocol yet exists for these, but a good starting place is 15 of each, once per day. As your strength improves, you can move to two or even three sets of 15 each. All exercises must be done SLOWLY!

2. General lower leg strengthening and balance
    a. Balance, possibly on unstable surface (foam pad, bosu ball)—start with 30sec or 1min, build as much as you like
    b. Mini-squats on a step, starting around 15 repeats and working to two or three sets
    c. Glute bridge—start with 10-12 10-second holds, build toward 2min continuous
3. Icing after each run
4. Quadriceps and calf stretching
5. Quadriceps and calf foam rolling
6. Patellar taping, either with traditional athletic tape or flexible kinesiology tape

Aggressive treatment:

These options are often more expensive or difficult to obtain and should be reserved for cases of PFPS that don't improve despite several weeks of strength work, rest, and other rehab.

1. Gait analysis at a physical therapy office equipped with a treadmill and a high speed camera to detect and correct gait abnormalities
2. Custom orthotics may alter your gait and relieve stress on your knee, but it is also possible that they may not help at all.

Return to Running

Patellofemoral pain is notorious for sticking around for weeks or even months, so do be cautious with this injury. In general, you don't want to run through pain. Sometimes, as you are recovering, your knee may feel a bit stiff at the beginning of a run, but as long as it gets better, not worse, as you progress in your run, you are probably okay to keep going. It's difficult or impossible to predict how much time off you'll need, especially considering the biomechanical roots of this injury. Most treatment plans that are published in scientific journals consist of 4-6 weeks of exercise and no aggravating activities (including running), but all cases of an injury are different. You may only need

a few days off if you catch it early, but if you've been running on PFPS for a while, you may need a lot longer. A good doctor or physical therapist can often give you a decent estimate of how long it will take you to return to running. In the meantime, you should stick to cross-training activities that don't hurt your knee. Aqua-jogging, biking, and using the elliptical are all options, but you'll have to see how these affect your knee. If a cross training activity hurts your knee, you shouldn't be doing it!

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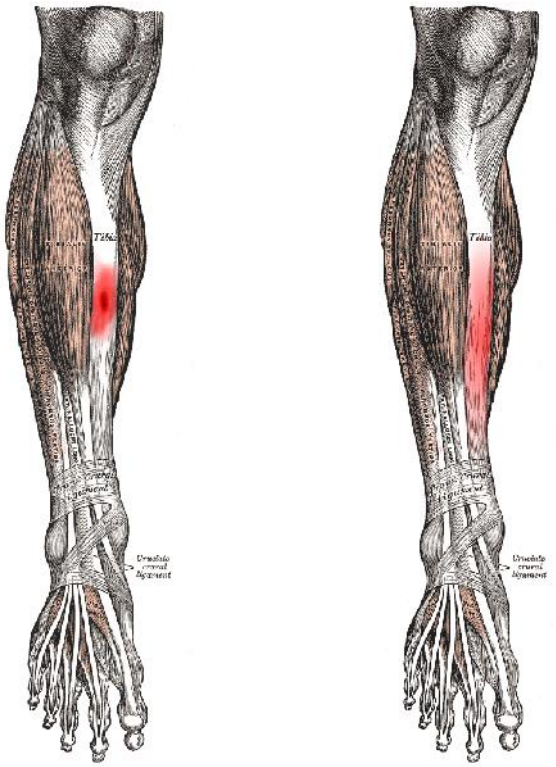
Medial Tibial Stress Syndrome ("Shin Splints")

About the injury



Medial tibial stress syndrome, sometimes referred to as "shin splints," is probably the most universally-known running injury. Shin splints classically present as an aching pain on the inside of the shin, near the border of the tibia and the calf muscles. The area will often be sore when poked or prodded, and will initially hurt at the end of a run. As the injury progresses, the pain will sometimes move to a more sharp, burning sensation, and may hurt during your entire run, or even when just walking around. Shin injuries can be diffuse, spreading out over many inches along the length of the tibia, or be localized to a small area less than two inches long. Serious cases of medial tibial stress syndrome, especially when localized to a small area, need to be distinguished from a tibial stress fracture, which can be accomplished with an MRI or a bone scan ordered by an orthopedist or podiatrist.

While not the most common running injury, medial tibial stress syndrome, or MTSS, still accounts for about 5-6% of all total injuries.[1, 2] Unlike many injuries, which seem to strike at runners of all fitness levels, MTSS is much more common among less experienced athletes. In a typical three-month high school cross country season, for example, between 12 and 15% of the runners on a typical team will suffer from MTSS.[3, 4] Woman are 2-3 times more likely to develop shin problems than men.[5] Additionally, among studies of military recruits, soldiers and sailors in poor physical condition (who likely have little history of athletic activity) are much more likely to suffer from shin splints.[6] In contrast, very few experienced runners have to deal with shin pain on a regular basis. Understanding the mechanism of injury can help explain why.

Causes, what makes it worse, what's going on

For a long time, MTSS was postulated to be a soft tissue injury. Many of the muscles of the lower leg, including the calves and the smaller muscles above the ankle, insert along the tibia. It was proposed that tightness or weakness of these muscles caused them to

tug at their insertion point, irritating the periosteum, a thin, skin-like structure that envelopes the tibia itself. This distinguished medial tibial stress syndrome from tibial stress fractures and stress reactions, which are indisputably true bone injuries. However, more precise anatomic studies have demonstrated that the muscular insertions blamed for causing shin pain do not correspond to the location of the injury;[7] instead, advanced medical imaging studies have illustrated that all overuse injuries to the tibia, from mild cases of "shin splints" to true stress fractures, exist on a spectrum of bony injuries. The most telling fact is localized bone density: in CT scans of the tibias of runners with shin pain, pockets of low bone density appear at the location of pain. After these runners have recovered, these pockets of low density have disappeared.[8] Additionally, runners with tibial stress *fractures* often have larger areas of lowered bone density around the fracture.

With this new information, scientists now hypothesize that the root cause of MTSS is repeated stress to the bone during running, caused not by straight-on impact, but a slight bending of the bone when it is loaded. Much like a beam on a bridge or in a skyscraper bows slightly when it's supporting a lot of weight, your tibia bends backwards slightly on impact with the ground, putting compressive forces on the medial side of the bone. In healthy runners, the bone stress after a long, hard run is not a problem. The body responds to the stress on the bone by remodeling the tibia to be stronger and thicker. This is why shin problems are more common in less-experienced runners: their bone has not yet adapted to the stresses of a high-impact activity like running. Unfortunately, this remodeling process takes several weeks to a few months to complete, and there is a period where the bone is actually *more* vulnerable to damage. Just like remodeling your house entails tearing out some walls before adding new construction, your body has to tear out some of the old bone tissue before strengthening it. As a result, having a small tibia or weak bones puts you at an increased risk for shin splints, since your weakened tibia is more vulnerable to injury when it is remodeling its bone structure.

Research backed treatment options

The current theories for treating and preventing medial tibial stress syndrome revolve around reducing the relative amount of stress on the tibia. Reducing impact and tibial loading, strengthening the supporting muscles, and strengthening the bone itself should all lower your risk of developing MTSS and may also speed recovery. Unlike some other running injuries, there are no solidly vetted treatment protocols. Rather, what follows is an extension of work on the precipitating factors for MTSS.

Reducing impact loading should be a priority for anyone with shin problems. Increasing your stride frequency by about 10% (bringing it close to 180 steps per minute or more) will markedly decrease the impact your tibia has to absorb each time your foot strikes the ground.[9] You might think that running on a softer surface or in more cushioned shoes would also reduce impact, but because the leg adjusts its stiffness to compensate, the actual forces going into the ground hardly change at all. In fact, there is even a little evidence that running in *thinner* shoes on a *harder* surface might be a better idea, since it lowers your leg stiffness![10]

Strengthening your calf and shin muscles might absorb some shock, reducing the strain on your tibia, but more importantly, will lead to a stronger tibia in response to the increased muscular strength and size. It's been demonstrated that female runners with a small calf circumference have a much higher risk of developing a tibial stress fracture,[11] so it is no surprise that runners with shin splints have poor calf strength.[12] While there is no set protocol as of yet for increasing calf strength, a program of standing calf raises to fatigue twice daily will go a long ways towards building your lower leg strength. There is also a lower-leg-strengthening routine of "foot drills" developed by Russ Ebbets, outlined below. These can also be done once or twice daily, and ought to be done barefoot on grass if possible.

lf strength and endurance:

Ebbets' six "foot drills":

1. Toes in

2. Toes out

3. Toes up

4. Heels up (walking backwards)

5. Inside up

6. Outside up

Other possible treatment options

With respect to orthotics, a few studies have demonstrated some success in using custom shoe inserts to treat MTSS.[13] This is a good sign, as many other injuries respond poorly to treatment with orthotics. Custom inserts might shift the distribution of pressure on the bottom of the foot, which may be associated with shin pain. Nevertheless, orthotics are not a panacea and shouldn't be your only treatment method. Many runners find good success with over-the-counter semi-rigid orthotics like the SuperFeet or PowerStep insoles, and these are much cheaper than custom orthotics, so give them a shot first.

Among more exotic treatments, extracorporeal shockwave therapy (ESWT) has emerged in recent years as a treatment possibility. In ESWT, shockwaves are applied directly to the tibia to encourage new bone growth. Only one study has tested ESWT, and it suffered from some design flaws, but it showed a significant reduction in recovery time.[14] ESWT treatment may be expensive and difficult to find, and its experimental evidence is still not up to snuff.

Outline of Treatment

Conservative treatments

These are methods that are fairly simple, inexpensive, and can be done on your own at home.

1. Work to reduce stress on the tibia by increasing your stride frequency by 10% or so to avoid overstriding and excessive impact.
2. Ice your shin using ice cups several times a day, and always after running
3. Calf raises starting with one set of 20 repeats and building to three sets of 20 (or more), twice per day.
4. Russ Ebbet's foot drill routine. 10m each, once per day:
    a. Toes in
    b. Toes out

   c. Toes up
   d. Backwards with heels up
   e. Inside up
   f. Outside up
5. Modify your training so you don't put as much stress on your tibia. Reducing mileage, intensity, and duration of your runs will all help. Remember, it can take several weeks to a few months for the tibia to heal.

Aggressive treatments

These are treatments with more cost and less certainty about outcomes, but may prove useful in recalcitrant cases.

1. Custom shoe orthotics or over-the-counter semi-rigid orthotics (SuperFeet, PowerStep) may be able to modify how forces are transmitted up the tibia, though this is unproven. Many runners find that orthotics greatly improve their shin pain, but possibly just as many find that they are no help.
2. Consider running in a thinner, firmer shoe on a harder surface. While the actual benefit for people with shin pain is as-of-yet unproven, biomechanics research has linked soft surfaces and soft shoes with higher leg stiffness, which is itself connected to higher shocks going up the tibia on impact.
3. Also consider taking a calcium/vitamin D supplement with 200% of your RDV of both. One study found that doing so reduces the risk of tibial stress *fractures* by 25%. Since MTSS is on the same "injury spectrum" as a tibial stress fracture, it's possible that supplementation can help prevent medial tibial stress syndrome too.[15]
4. If conservative treatments don't help, you also should be evaluated by a doctor for a tibial stress fracture. X-rays are very inaccurate for diagnosing stress fractures, so your doctor should use either an MRI or a bone scan. MRIs are slightly more accurate and allow your doctor to get a better idea of the severity of the injury, so they are generally the preferable imaging technique.

Return to running

You will need to modify your training program to allow your body time to strengthen your shin bone. Mild cases of MTSS may only require modifying your running form and doing some lower leg strength, but more serious cases will require at least a few weeks off. Keep in mind that shin splints are the same type of injury as a stress fracture, so if you feel like your shin injury is getting worse, you should not continue to run on it. While many coaches recommend that a "10% rule" for increasing mileage is best to avoid injury, the dynamics of the tibia's healing mechanism suggest that perhaps a stress/adaptation cycle would be better. So, instead of increasing mileage every single week by 10%, you might increase by 10% for three weeks, then take a "down week" to allow your tibia to recover (ex. 40mi-45-50-40-50...). Another option would be an

"equilibrium" style buildup, as favored by Jack Daniels, where you maintain the same mileage for 3-4 weeks, then make a larger jump of 20-30% (ex. 30mi-30-30-40-40-40...). When returning to running, you should be conservative when building back your mileage.

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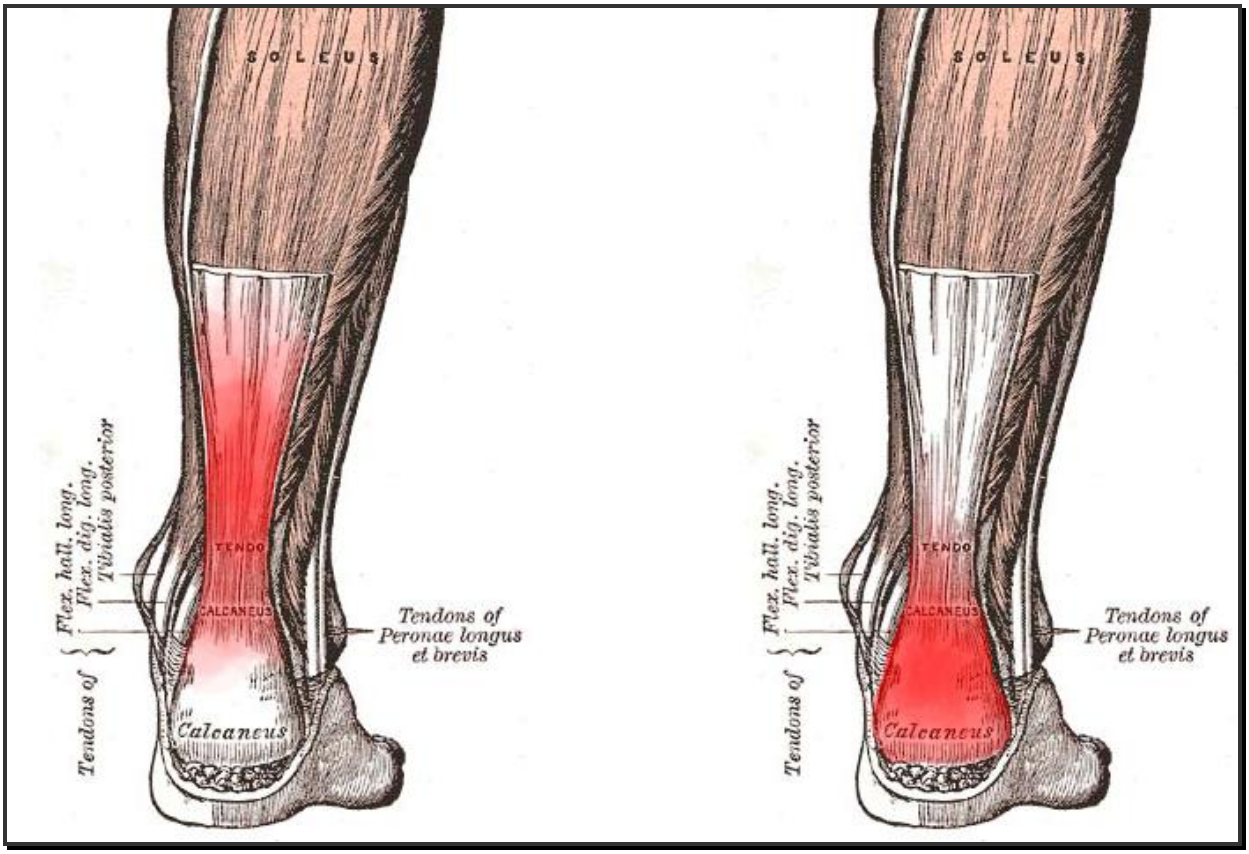
Achilles Tendonitis



Pain associated with midpoint Achilles tendonitis (left) and insertional Achilles tendonitis (right).

The **Achilles tendon** is the thickest and strongest tendon in your body, connecting your calf muscles to the back of your heel. Virtually all of the force generated when you "toe off" the ground during running is transmitted by the Achilles, and this force can be as much as three times your body weight. And the faster you run, the more strain you put on the Achilles tendon. As such, it's prone to injury in many runners, but particularly those who do a lot of fast training, uphill running, or use a forefoot-striking style.

Achilles tendon injuries account for 5-12% of all running injuries,[1,2] and occur disproportionately in men. This may be because of the faster absolute speeds men tend to train at, or may be due to other biomechanical factors.

Achilles tendonitis typically starts off as a dull stiffness in the tendon, which gradually goes away as the area gets warmed up. It may get worse with faster running, uphill running, or when wearing spikes and other low-heeled running shoes. If you continue to train on it, the tendon will hurt more sharply and more often, eventually impeding your ability even to jog lightly.

About two-thirds of Achilles tendonitis cases occur at the "**midpoint**" of the tendon, a few inches above the heel. The rest are mostly cases of "**insertional**" Achilles

tendonitis, which occurs within an inch or so of the heelbone.[3] Insertional Achilles tendonitis tends to be more difficult to get rid of, often because the bursa, a small fluid-filled sac right behind the tendon, can become irritated as well.

The root cause of the problem

The causes of Achilles tendonitis all appear to be related to excessive stress being transmitted through the tendon. Weak calf muscles, poor ankle range of motion, and excessive pronation have all been connected with the development of Achilles problems.[3], [4] The upshot is that all of these factors, plus training volume and so on, result in damage to the tendon.

While the term "tendonitis" implies that inflammation (*-itis*) is the root cause of the problem, in fact, the true cause is real, physical damage to the fibers of the Achilles tendon itself. Much like a bungee cord is made up of tiny strands of rubber aligned together, tendons are comprised of small fiber-like proteins called collagen. Pain in the Achilles tendon is a result of damage to the collagen. Because of this, treatment options should start with ways to address this.

Research-backed treatment

For a long time, researchers and doctors muddled about trying to address factors like calf strength & tightness, ankle range of motion, and pronation, assuming that the Achilles tendon would heal itself once these factors were corrected. Unfortunately, it seems that the thick tendons of the body do not heal as rapidly or completely as we'd like. The cause of this seems to be the collagen fibers: when a tendon is damaged, collagen fibers are ruptured. The body is able to lay down new fibers to replace the damaged ones, but it does so in a rather disorganized way. The new collagen fibers look much like a mess of spaghetti when viewed on a microscope, in contrast to the smooth, aligned appearance that healthy tendon fibers have.

So, while we might propose that runners do calf stretching to loosen up their calf muscles and increase their ankle range of motion, this often does more harm than good—tugging aggressively on the damaged tendon fibers is much like pulling on either end of a knotted rope. Instead, the main objective in treating Achilles tendon injuries should be healing the damaged tendon. The exercise of choice is the eccentric heel drop, which has an impressive research pedigree backing its use.[5]

Eccentric heel drop protocol

The strength protocol consists of two exercises: a straight-kneed and a bent-kneed eccentric heel drop. The protocol calls for three sets of fifteen heel drops, both bent-kneed and straight-kneed, twice a day for twelve weeks.

Standing on a step with your ankles plantarflexed (at the top of a "calf raise"), shift all of your weight onto the injured leg. **Slowly** use your calf muscles to lower your body down, dropping your heel beneath your forefoot. Use your uninjured leg to return to

the “up” position. **Do not** use the injured side to get back to the “up” position! The exercise is *designed* to cause some pain, and you are encouraged to continue doing it even with moderate discomfort. You should stop if the pain is excruciating, however. Once you are able to do the heel drops without any pain, progressively add weight using a backpack. If you are unlucky enough to have Achilles tendon problems on *both* sides, use a step to help you get back to the “up” position, using your quads instead of your calves to return up.

Exercise 1: The straight-knee eccentric heel drop.

In this picture, the injured side is the left leg. Note that the *right* leg is used to return to the “up” position. This exercise is one of two used in cases of midpoint Achilles tendonitis. Once you can perform this exercise pain-free, add resistance using weights in a backpack.

Exercise 2: The bent knee eccentric heel drop.

As with exercise 1, the opposite leg is used to return to the "up" position (not pictured). This is the second exercise for midpoint Achilles tendonitis. Add weight when you can do it pain free.

Exercise 3: Modifications for insertional Achilles tendonitis

In the case of insertional Achilles tendonitis, the protocol is modified a bit: the exercise is done on *flat ground,* and only the straight-legged variant is done. All other aspects are identical (3x15 twice daily, adding weight, and so on).[6]

Exercise 3: the flat-ground eccentric heel drop. This exercise is used for cases of insertional Achilles tendonitis, replacing exercises 1 & 2. Like the exercises for midpoint Achilles tendonitis, use the opposite leg to return to the "up" position and add weight once you can do it pain-free.

The eccentric exercises are thought to *selectively* damage the Achilles tendon, stripping away the misaligned tendon fibers and allowing the body to lay down new fibers that are closer in alignment to the healthy collagen in the tendon. This is why moderate pain during the exercises is a *good thing*, and why adding weight over time is necessary to progressively strengthen the tendon.

Other possible treatment options

While you are addressing the damage to the tendon fibers through eccentric heel drops, there are some steps you can take to help ameliorate some of the other contributing factors to your injury. While calf tightness and ankle range of motion are legitimate concerns, I still don't think that aggressive calf stretching is an ideal solution, because of the tugging action on the tendon. Instead, try foam rolling your calves and applying a warm water bag to the muscle (but avoid heating the tendon!). You can also stretch out your shins by leaning back in a kneeling stance to aid ankle range of motion.

Foam rolling your calf muscles can loosen them up without tugging too much on the Achilles tendon.

Footwear concerns should also be addressed at this point. If you have been wearing low-heeled "minimal" shoes, racing flats, or spikes, you ought to stick to more traditional shoes with a higher heel until your tendon is healthy again. Once you've healed up, you can gradually do some running in low-heeled shoes or even barefoot (on grass) to help accustom your Achilles to moving through its full range of motion. Poor casual footwear choices should not be overlooked too, especially for women. Some shoes can also put pressure on the back of your heel, irritating the insertion of the tendon. Generally, the closer a shoe is to looking and feeling like a "running shoe," the better it is for your foot.

Doctors and podiatrist may be keen to have you try out a heel lift or a custom orthotic to treat your Achilles problems. While it might be worth a shot, there isn't a whole lot of scientific evidence backing their use in this case. Orthotics don't reliably alter pronation,[7] and even if they do, it's uncertain as to whether this will increase or decrease stress on the Achilles. And heel lifts also have a variable effect—it's not clear whether they actually remove much stress from the Achilles tendon.

Outline of treatment

Conservative treatments

These are cheap, easy to perform treatments that you can do it home in your own time. You should try to do as many of these as possible each day.

1. Eccentric heel drops – 3 sets of 15 reps, twice per day for 12 weeks (if you only do one thing, do this!)
2. Icing after each run
3. Heating before each run with warm water or heating pack
4. Contrast bath during the day - take two small buckets/trash cans and fill one with hot (hot bath temp) water and the other with ice water (cold enough so some ice still doesn't melt) and put your whole leg (up to the calf) in the cold. Hold for 5 minutes and then switch to the hot for 5 minutes. Repeat 2 or 3 times, ending with cold. This helps rush blood in and out of the area, which facilitates healing

5. Don't take anti-inflammatory like Advil or ibuprofen. These stop the body's natural healing agents and we want as much natural healing to occur as possible.
6. Avoid excessive stretching – only very light, easy stretching until healed
7. Massage your calves with a foam roller or The Stick.
8. Heel lifts are a possible temporary solution. They restrict the Achilles' range of motion, so can be helpful to get over the initial hump of the injury, but should be taken out after you are recovering.
9. Switch to more supportive or traditional running shoes (higher heels) during your runs and while walking around until your pain is completely gone, and avoid flats and high heels!
10. Ankle strengthening and mobility exercises.

Aggressive treatments

These treatments are a little more expensive or time consuming and are only suggested for if you suffer from chronic Achilles pain or the conservative treatments are not working for you.

1. A custom orthotic might help alleviate the pain from excessive pronation. This is not a proven treatment, but for those runners who respond to orthotics, it can help.
2. Iontophoresis with dexamathasone. This is a treatment offered by physical therapists that involves propelling anti-inflammatory steroids into the tendon. You need a prescription and a physical therapist to administer the treatment, but research has shown the potential[8] to have a positive effect on the treatment of Achilles issues.
3. Sleep in a Strassburg sock or nightsplint to gently stretch the Achilles while sleeping.

Strengthening and prevention

1. Eccentric heel drops
2. Ankle strengthening and mobility exercises
3. Achilles rehab exercises

Returning and continuing to run

You can still run during this twelve-week period, but only if your Achilles does not flare up while doing so. Use warm water to heat up the tendon before you run, and apply ice afterwards, even once you've started feeling better. Using a foam roller and hot water packs to loosen up your calves in the morning and at night is also not a bad idea, and don't forget to take a look at what you're wearing in your daily life. If you have insertional Achilles tendonitis, use the modified flat eccentric heel drop exercise instead of the two variants off a step. A custom orthotic or heel lift may be helpful, but should not be a first-line treatment option.

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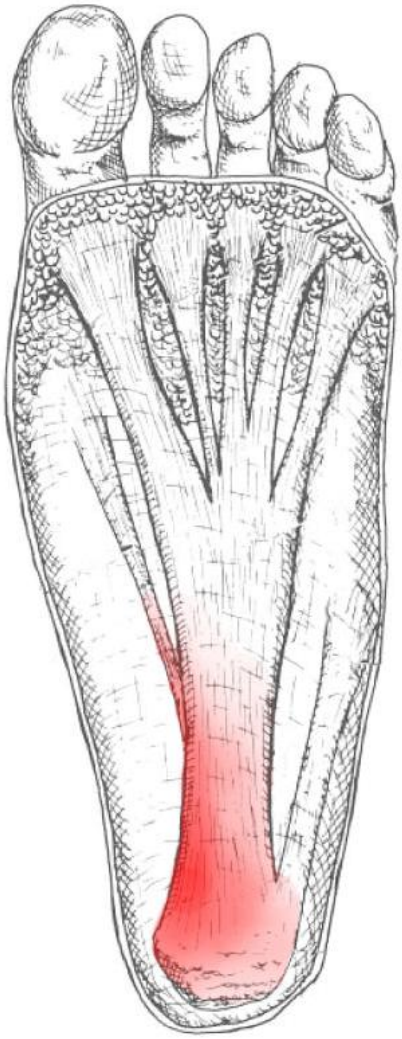
Plantar Fasciitis

Part 1: About the injury

Plantar fasciitis, an irritation to the tough, fibrous tissue at the base of the heel, is one of the most bothersome running injuries due to its infamous stubborn nature. Athletes with plantar fasciitis can sometimes have heel pain for months or even years before the fascia finally heals. Because of this, it is very important to catch and treat plantar fasciitis quickly. Fortunately, with proper treatment, most cases do come around in a matter of weeks.



The plantar fascia is a thick band of fibers that runs from the base of the heel to the metatarsal heads. It has several branches, any of which may become injured, but by far the most common area of the plantar fascia that's hurt is the very base of the innermost bundle of fibers, right at the base of the heel. Plantar fasciitis will hurt the worst at the beginning of a run, but will gradually go away once you get warmed up. It may return again at the end of the run, and will be more severe in less-supportive shoes or when barefoot. Your arch or heel may also hurt after a long day on your feet, especially in hard or uncomfortable shoes. The most tell-tale symptom is "first step pain": a sharp, stabbing pain at the base of the heel immediately after you get out of bed in the morning.

Plantar fasciitis accounts for around eight percent of all running injuries,[1] and is common among runners of all ability levels, and is even a problem for sedentary people, where obesity and working long hours while standing are probably the driving causes. Runners, of course, face additional issues due to the forces associated with running, but you shouldn't overlook your footwear or habits in the rest of your life if you come down with a case of plantar fasciitis. Women's footwear is especially bad with respect to strain on the arch, but unsupportive hard-soled men's shoes are problematic too.

Part 2: Causes, what irritates it, what's happening

Unfortunately, the root causes of plantar fasciitis are still not fully understood. There are, however, some clues. Some studies have found a connection between poor ankle range of motion, especially in dorsiflexion,[2, 3] which implies that calf tightness plays a role in the development of plantar fasciitis. Indeed, the plantar fascia itself is in many ways simply a continuation of the Achilles tendon, which anchors the calf muscles to the heel bone. Like a cable that angles around a corner, tight calves could put excessive tension on the plantar fascia, increasing the risk of injury. As mentioned earlier, obesity and time spent on your feet are risk factors as well,[2] though these are not as often a problem for runners. However, they do indicate that putting high strains on the foot is problematic, and new research out of the University of Delaware has connected high impact loading rates with plantar fasciitis.[4]

The plantar fascia is also forced to absorb significantly more strain when you wear hard, flat shoes or walk around barefoot. While the dynamics of "arch support" are not fully understood from a biomechanical perspective, it's fairly obvious to most sufferers of arch pain that a cushioned, supportive surface feels better on the foot than a hard, flat one.

Part 3: Research backed treatment options

To that end, the first goal of treatment should be to protect the plantar fascia from additional strain while it is injured. While the "-itis" suffix implies that inflammation is the cause of plantar heel pain, new evidence indicates that the real problem is damage and degeneration of the fascial fibers[5]—icing is always a good idea, but it's not an excuse to continue to strain the plantar fascia with long runs, hard workouts, or unsupportive shoes. Aggressive rehabilitation, combined with avoiding activities that hurt, are your best chance for a speedy recovery.

Several conservative treatment methods are supported by scientific research. These treatments are all designed either to protect the arch or stretch the plantar fascia/calf muscle complex.

Several studies support arch taping, called "low-Dye taping" in medical circles after Ralph W. Dye, the inventor.[6] While there are several ways to do a low-Dye taping, even its most basic form is effective. The magnitude of the effect, however, is small, so arch taping is only one part of a rehabilitation plan.

Instructions for a low-Dye taping. The lateral straps (lower left, lower right) should be pulled reasonably firmly and should always come FROM the outside of the foot TO the inside.

Supporting the arch with a custom or over-the-counter orthotic is another strategy that can protect the arch while it heals. It's unclear whether there is a significant difference between custom orthotics or a rigid over-the-counter orthotic like SuperFeet Green or Powerstep insoles when it comes to treating plantar fasciitis.[7] While they may not be tailored for your foot, over-the-counter insoles are not nearly as expensive and are available immediately—you'll have to wait at least a few weeks for a pair of custom orthotics. Avoid soft gel arch supports, as they'll likely do nothing to help your injury. In a similar vein, many runners find that wearing casual shoes with more arch support (including Birkenstocks and other brands of cork-soled shoes/sandals) relieves their symptoms.

Calf stretching, foot stretching, and using a night splint are the final three conservative treatments vetted by research. All three treatments are designed to stretch out the calf/Achilles/plantar fascia complex, reducing tension and strain on the arch.

For lack of any superior exercise, regular calf stretching is the mainstay of most plantar fasciitis treatment programs. Calf stretching should be done several times a day, including right away in the morning. A typical protocol would be three sets of 30 seconds, three times per day, stretching with the knee straight and bent each session.

Calf stretches, with both a straight knee (top) and a bent knee (bottom)

One study compared a calf stretching protocol to a plantar fascia-specific foot stretch, held for 10x10 seconds, three times per day, and pictured below.[8]

Plantar fascia-specific stretch. Note that all the toes are stretched, not just the big toe.

This study found better results from the plantar fascia specific stretch; the authors hypothesized that the advantage of the foot stretch is that it recreates the Windlass mechanism, the pulley-like connection between the plantar fascia, heel, Achilles tendon, and calf.

Night splinting is another treatment which aims to stretch out the plantar fascia. As its name suggests, a night splint is a device you wear while you sleep which keeps your ankle dorsiflexed. The theory is that the "first-step pain" that is the hallmark of plantar fasciitis is caused by the arch healing at night without any tension on it. In the morning, the healing is disrupted by the tension put on the arch when you get out of bed. Solid, cast-like night splints are available online and at a few specialty stores, but the Strassburg Sock is an easier and more practical solution.[9] "The Sock" is a regular knee-high sock with a strap that runs from the toes to the kneecap. When this strap is (gently) tightened, the ankle is dorsiflexed like in a regular night splint, but so are the toes. A Strassburg sock can be ordered online or often picked up at your local running store.

A Strassburg Sock in use. Be careful not to put excessive tension on the strap.

Part 4: Other possible treatment options

Manipulating the tissue of the plantar fascia is an approach that's become more popular among runners recently. Using a golf ball or other hard, round object, you can "roll out" your arch much like you'd roll out your quads or calves with a foam roller. More aggressive soft-tissue manipulations like Active Release Technique (A.R.T.) or Graston Technique are also popular. All of these are unproven in the scientific literature, however, so while many runners do find them very helpful, there's no evidence they'll work for you. If you do decide to roll out your arch or get some soft tissue work done, icing your foot afterwards is not a bad idea.

Injections of corticosteroids are a common second-line treatment among podiatrists. While some research has showed that they may help,[7] other scientists have urged caution, since their success rate is fairly low and there is a risk of complete rupture of the plantar fascia.[10, 5] Application of a corticosteroid like dexamethasone through the skin via iontophoresis, an electric charge-driven process, may be more helpful and have a lower risk of complications than a direct injection.[11] This is an issue you should talk with your orthopedist or podiatrist about.

Chronic, long-standing cases of plantar fasciitis can be particularly tricky to deal with. Two new treatments, extracorporeal shockwave therapy (ESWT)[12, 13, 14]and platelet-rich plasma therapy (PRP),[15] show good promise in treating recalcitrant cases, especially in runners. Because of their relatively recent development, they may be difficult to get access to, however, and their efficacy is not yet solidly vetted.

Part 5: Outline of treatment options

Because of plantar fasciitis' reputation for hanging around for months at a time if not properly addressed, even a mild case of arch pain should be attacked aggressively with several treatments. Protection, ice, and stretching should be the mainstays of your early treatment. While you don't have to completely cease physical activity, you should avoid anything that makes your arch worse, and protect it while you run and while you go about your daily life.

Conservative treatments:

These are methods that are fairly simple, inexpensive, and can be done on your own at home.

1. Wear comfortable shoes with some cushioning and arch support, and avoid hard shoes or anything barefoot.
2. Ice your foot several times a day, either with ice cups or a round, frozen object like a plastic water bottle. If you run, ice immediately afterwards.
3. Stretch your calves at least three times per day. Each session should consist of 3x30 second holds, first with your knee straight, then with it bent.
4. Stretch your plantar fascia three times per day. Each session should consist of 10x10 second holds. Make sure you stretch right after getting up in the morning.
5. Use a low-Dye taping to protect your arch when you walk around or exercise.
6. Consider using an over-the-counter orthotic like SuperFeet Green or Powerstep in your everyday shoes and running shoes.
7. Wear a night splint or a Strassburg Sock at night to stretch out your arch, Achilles, and calf muscles.
8. Roll out your plantar fascia with a golf ball, taking care not to press too hard on the injured area.

Aggressive treatments:

These are treatments with more cost and less certainty about outcomes, but may prove useful in recalcitrant cases.

1. Consider seeing a podiatrist and getting custom orthotics made. They have a large up-front cost and may take a few weeks to arrive, but many runners credit their recovery to orthotics.
2. Talk with your doctor or podiatrist about the risks and benefits of a corticosteroid injection or, preferably (to reduce the risk of plantar fascia rupture), iontophoresis.
3. Seeing an A.R.T. or Graston Technique practitioner may speed your recovery, though there's no research to back these treatments
4. Look into extracorporeal shockwave therapy or platelet rich plasma injections for particularly stubborn cases

Return to running

How quickly you can return to running will depend on the severity of your injury and how fast you heal. Some runners find that they can work their way back into running even while some residual arch stiffness persists, but if running is making your arch pain worse, you need more time off and more time for your rehab program to do its job. As you return to running, consider increasing your stride frequency by 10% or so to reduce your impact loading rate,[16] a factor connected with the development of plantar fasciitis in runners. Keep stretching your calves even after you've recovered to stave off any future bouts with plantar fasciitis.

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Stress Fractures

A stress fracture is one of the most frustrating injuries a runner can come down with. While bad cases of some injuries do have a reputation for sticking around longer than the duration of a normal stress fracture, a stress fracture is a much bigger baseline setback than most soft tissue injuries: at least six weeks of no running at all—some of your time off may even need to be on crutches or in a "boot."

As the name suggests, a stress fracture is a small crack in any of the weight-bearing bones of the body. Runners can get a wide variety of stress fractures, but the most common locations are (in order) the tibia, the metatarsals, the femur, the fibula and the navicular.

Varying degrees of stress fractures

Stress fractures can be grouped into "low risk" and "high risk" categories.

A low risk stress fracture will typically heal on its own just fine, and may not even require any time spent in a boot or on crutches. Low risk stress fractures include most types of tibial stress fracture, fibular stress fracture, and metatarsal stress fracture.

A high risk stress fracture, however, is one in an area which is known to heal poorly. Stress fractures to the navicular, pelvis, and femur, however, are often high-risk, and tend to require significantly more time away from running and a more cautious approach to returning to running. Fortunately, these high-risk stress fractures are rarer than the low-risk types.

Stress fractures above the knee are particularly troubling from a medical standpoint, as the femur, pelvis, and low back are among the strongest bones in the body. A stress fracture to these areas may indicate underlying medical problems.

Why runners are prone to stress fractures

Bone, like most tissue in the body, can adapt and become stronger when it's subjected to a stress. However, unlike muscles and tendons, which can adapt and strengthen in a period of days or weeks, it takes many months for bone to become stronger after it's been put under an increased level of stress.

In fact, there's even a window of about a month where bone becomes *weaker* after an increase in training stress because of the way the body remodels bone. Your body first tears out some walls in the bone structure before it can put in new ones, much like remodeling your house.

A stress fracture typically feels like an aching or burning localized pain somewhere along a bone. Usually, it will hurt to press on it, and the pain will get progressively worse as you run on it, eventually hurting while walking or even when you're not putting any weight on it at all. Sometimes, if the stress fracture is along a bone that has a lot of muscles around it, like the tibia or femur, these muscles will feel very tight.

If you suspect you have a stress fracture, you should see an orthopedist as soon as possible to get it diagnosed. **X-rays are nearly useless for diagnostic purposes, so your**

doctor should conduct a bone scan or, preferably, an MRI to confirm the presence of a stress fracture.

While bone scans are highly accurate and reliable, they are very expensive. An MRI can allow your doctor to get a better idea of the severity of your stress fracture, which might allow him or her to give you a better estimate of when you can return to training.

Sometimes, you can catch a stress fracture early on—at this point, it is classified as a **stress reaction** and may only require a few weeks' time away from running. It's very important to heed your doctor's advice, since continuing to run on a stress fracture can cause it to progress to a *real* bone fracture, which will land you on crutches for several months and will put any future running in real jeopardy. This is especially true with high-risk stress fractures.

What causes stress fractures

The scientific literature is unclear on whether the main cause of stress fractures is *impact* loading forces or *active* forces.

Impact loading force is the degree of shock that travels up your foot and leg when you initially hit the ground, while active forces are generated when you are pushing your body off the ground.

Some research has found that runners with a history of tibial stress fractures have high impact loading rates, while other studies have predicted that the strain on the bones of the body is greatest when pushing off the ground. Fortunately, these two are not mutually exclusive—strategies that can reduce impact loading rates will also likely reduce active forces.

Because there's no known treatment, aside from rest, that can speed your recovery from a stress fracture, most research has been directed at methods to prevent a stress fracture in the first place (or avoid another one in the future). Strategies for prevention are mostly focused on reducing the stress on your bones and building or maintaining their strength.

Avoiding stress fractures

Since a stress fracture is a fairly serious injury, sustaining one warrants a thorough examination of your training, running mechanics, and overall health.

First off, you need to examine your training history to see if you made any drastic changes in mileage or intensity in the past month or so.

As mentioned in the introduction, when bone is stressed, it is actually *weaker* for about a month after a change in training stress before it becomes stronger. Become of this, it may make more sense to change up how you increase mileage.

While the traditional recommendation is a 10% increase in mileage every week, the dynamics of bone remodeling suggest that taking "down weeks" every 3-4 weeks with a 10-20% *drop* in mileage might be a better idea. A series of weeks under this model might look like this:

36mi-40mi-44mi-36mi-44mi...

Another option is an “equilibrium” model, where mileage jumps 20-30% every 3-4 weeks, but with no change of mileage in the intermittent weeks. A series of weeks under the equilibrium model might look like this:
30mi-30mi-30mi-40mi-40mi...

Other risk factors for stress fractures

But training is far from the only important factor. Many runners can run well over 100 miles a week without developing a stress fracture, while others come down with them at 15 or 20 miles a week.
One reason changes in training *do* play a role is that the bone’s capability to handle stress is directly related to its size and strength.
Multiple studies have connected narrow, weak bones with an increased risk of stress fracture. Furthermore, it appears that the *muscles surrounding* a bone influence its size and strength as well.
One study found that women with a larger calf circumference are at a lower risk of tibial stress fracture, and another found that women with larger muscular cross-sectional area in their calf were at a lower risk of any *kind* of stress fracture.
While you probably won’t be able to do any strength training during your recovery, improving the strength, size, and endurance of the muscles in your legs—especially your calves—is a good strategy for the future.
The *speed* at which you train is also something to take into consideration. Many dedicated runners run themselves into trouble by maintaining a fast pace on many of their runs. Since both impact and active forces have been connected to stress fractures, it makes sense that a faster training pace would make you more vulnerable: running fast necessarily means incurring greater impact and active forces when your feet hit the ground. If you are a speed demon on your easy days, think about dialing back the pace once you’re beginning your comeback.
Stride frequency is another factor that affects your impact and active forces. To run a given pace with a low stride frequency, you’ll be hitting the ground and pushing off harder than if you were running with a higher stride frequency. Of course, there are upper limits on how high of a stride frequency you can maintain. But elite runners (and, in my experience, runners who are better at avoiding injury) tend to maintain a stride frequency of 180 steps per minute or more, even at slow paces.
Finally, stress fractures may be indicative of underlying health issues, especially in women. Because of the hormonal dynamics of the menstrual cycle, women who miss their period because of insufficient caloric intake in their diet are at a significantly higher risk for sustaining a stress fracture. If you are amenhorreic (missing your monthly period), you should talk to your doctor as soon as possible, as it can affect not only your immediate injury risk, but your bone density for the rest of your life, which is a problem much bigger than a running injury.

Recovery and treatment of stress fractures

If you suspect you have a stress fracture, you need to see a podiatrist or an orthopedist to have it diagnosed. They will be able to determine the exact location and severity of your stress fracture, as well as what, if any, protective measures (boot, crutches, etc.) you will need to take while it heals.

It is *exceptionally* important to heed the advice of your doctor when it comes to stress fractures, because pushing too hard on a stress fracture can put your running in jeopardy for months to come.

While you recover, your doctor will probably lay out a schedule of when you can return to various cross-training activities. Some non-weight bearing cross training methods, like aquajogging, can often be started right away, though you may have to wait several weeks to be able to use the elliptical or exercise bike. Again, this depends on the specifics of your stress fracture, and is something you'll want to ask your doctor about.

Maintaining your aerobic fitness while you are injured is not always fun, but will make your comeback a lot easier once you've been cleared to run again.

Use your recovery time to review your training, diet, and lifestyle to identify factors that might have contributed to your injury.

Taking a calcium and vitamin D supplement which provides 200% of your RDV of both nutrients is not a bad idea either, as a 2007 study found that this can reduce the risk of a stress fracture in female Navy recruits.

As you return to running after your time off, examine your running form, with particular attention to your stride rate and usual training pace, since a low cadence or excessively fast everyday speed can increase loading through your foot, lower leg, thighs, and hips, causing problems if you are susceptible to stress fractures.

Outline of preventative measures

Conservative measures

These are simple, well-backed by research, and carry a relatively low risk of extra complications. These preventative measures should be taken by anyone who's suffered a stress fracture, or believes that they are at risk for one.

1. Examine your training to see whether you made any drastic changes in volume or intensity in the past month or so. These may have caused your stress fracture, as bone becomes *more* vulnerable to injury in the month following an increase in stress. Consider changing to a training model which includes "down weeks" every 3-4 weeks or an "equilibrium" model which maintains new levels of mileage for longer before increasing again.
2. Check your stride frequency by counting how many times your right leg hits the ground in 30 seconds while running, then multiplying by four. Ideally, you'd be

hitting 180 steps per minute or more. If you are significantly lower than this, do your best to increase your cadence by 5-10%. This will decrease the loads that have to be carried by your joints and bones.

3. Speak with your doctor to see whether you have any underlying health issues that could have contributed to your stress fracture. This is especially relevant for women, for whom amenorrhea is a major concern and also a major health risk even outside of running.
4. Once you have recovered, incorporate more lower-body strength training into your regimen. Muscle size and strength are linked to bone size and strength; additionally, there is some evidence that stronger muscles will absorb more shock, leaving the bone less vulnerable to high impact loading.
5. Re-examine lifestyle issues like a lack of sleep and improper diet which could impede your body's ability to repair your bones.

Aggressive prevention measures

These are preventative measures that have some backing evidence, but it is either circumstantial or only indirectly linked to bone stress. Additionally, they may carry the risk of increasing your risk for other injuries. If you have suffered multiple stress fractures and have not had success preventing them with conservative measures, consider trying these.

1. Try using a custom orthotic if you have a history of tibial or metatarsal stress fractures. Some doctors have proposed that custom orthotics can alter how forces are transmitted up your leg, *theoretically* leading to lower peak stresses on the bone. Be aware that this theory currently has no experimental evidence to back it up!
2. Alternatively, if you have a history of tibial or fibular stress fractures, you may also consider running in thin, low-profile "minimalist" shoes. Wearing a thin shoe will force you to maintain a high stride frequency, and will also encourage a midfoot or forefoot strike, which should reduce impact loads on your leg. The tradeoff for this is increased stress on your foot and metatarsals; some doctors have warned that wearing minimalist shoes can even increase your risk for a metatarsal stress fracture.
3. Take a calcium and vitamin D supplement that provides 200% of your RDV of both. This carries a small risk of kidney stones if your dietary calcium intake is already high, however.
4. Change the surface you typically run on. Many runners anecdotally report that soft, natural surfaces like dirt trails and grass fields feel kinder on their bodies than hard, even surfaces like roads and sidewalks. However, there's no experimental evidence that runners that train on any particular surface are more or less at risk for injury. In fact, there's some suggestion that soft surfaces may *increase* the loading on your bones somewhat, as they demand your body maintain a higher overall leg stiffness. This may be counterbalanced by the fact that soft surfaces are usually more irregular, and hence stress your body slightly

differently every step. You'll have to experiment with running surfaces to see what type you feel is more beneficial for you.

Returning to training

When it comes to returning to running, you will have to follow the directions of your doctor. Typically, stress fractures require 6-8 weeks away from running.
Once you begin to run again, you will likely start with very short sessions with alternating bouts of walking and jogging. One example might be six sets of 5min, each consisting of 1min of jogging and 4min of walking. This can gradually build up to 3-4min of jogging per 1min walking, and eventually progress into continuous runs.
Here is a sample 4 week return from stress fracture training schedule

Monday	3 x 9 min walk, 1 min run + core + hips + lower leg strength
Tuesday	60 min ellipical medium
Wednesday	45 min elipitcal easy, 45 mins bike hard
Thursday	3 x 9 min walk, 1 min run + core + hips + lower leg strength
Friday	2 hours moderate bike/elliptical - simulate long run
Saturday	4 x 9 min walk, 1 min run + core + hips + lower leg strength
Sunday	Cross training - outdoors
Monday	3 x 8 min walk, 2 min run + core + hips + lower leg strength
Tuesday	60 min ellipical medium
Wednesday	45 min elipitcal easy, 45 mins bike hard
Thursday	4 x 8 min walk, 2 min run + core + hips + lower leg strength
Friday	2 hours moderate bike/elliptical - simulate long run
Saturday	4 x 8 min walk, 2 min run + core + hips + lower leg strength
Sunday	Cross training - outdoors
Monday	4 x 6 min walk, 4 min run + core + hips + lower leg strength
Tuesday	60 min ellipical medium
Wednesday	45 min elipitcal easy, 45 mins bike hard
Thursday	5 x 6 min walk, 4 min run + core + hips + lower leg strength
Friday	2 hours moderate bike/elliptical - simulate long run
Saturday	5 x 5 min walk, 5 min run + core + hips + lower leg strength
Sunday	Cross training - outdoors
Monday	6 x 5 min walk, 5 min run + core + hips + lower leg strength
Tuesday	60 min ellipical medium
Wednesday	45 min elipitcal easy, 45 mins bike hard
Thursday	6 x 5 min walk, 6 min run + core + hips + lower leg strength
Friday	Off - rest day
Saturday	3 mile run
Sunday	Cross training - outdoors

You may experience some mild soreness in your initial runs because of the scar tissue and bone remodeling that's happening at your injury site, but it should not resemble the pain you initially felt when you had a stress fracture. As long as the pain is mild, goes away quickly after your , and isn't a dull lingering pain, you should be ok. Return to your doctor if you continue to have pain at the site of your injury.

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