

Evaluation and Treatment of Biking and Running Injuries

Sean M. Oser, MD, MPH^a, Tamara K. Oser, MD^a,
Matthew L. Silvis, MD^{a,b,*}

KEYWORDS

• Running • Cycling • Biking • Injuries

KEY POINTS

- As more individuals participate in running-related and cycling-related activities, physicians must be increasingly aware of the common injuries encountered in these pursuits.
- Training errors lead to most running and biking injuries.
- History and physical examination are often adequate for proper diagnosis and management of running-related and cycling-related injuries.
- Imaging can sometimes help assist in differentiating among diagnoses with similar clinical presentations or to determine degree of injury.
- Correct ergonomics, including bike fit and equipment, and training/technique should be emphasized, and errors in these areas should be corrected when treating injured cyclists.

INTRODUCTION

Exercise is universally recognized as a key feature for maintaining good health. Likewise, lack of physical activity is a major risk factor for chronic disease and disability, an especially important fact considering our rapidly aging population.¹

Obesity has become a major health problem facing the US population. Approximately 36% of adults in the United States are obese, with an additional 33% overweight and therefore at increased risk for becoming obese.² More than 1 in 6 US adolescents are obese, and less than 50% of children meet exercise guidelines recommended by the American Academy of Pediatrics.³

Physicians are increasingly recommending cardioaerobic fitness activities for their health benefits. The popularity of aerobic exercise, including running and biking, has

^a Department of Family and Community Medicine, Penn State Milton S. Hershey Medical Center, 500 University Drive, Hershey, PA 17033, USA; ^b Primary Care Sports Medicine, Department of Orthopedics and Rehabilitation, Penn State Milton S. Hershey Medical Center, H154, 500 University Drive, Hershey, PA 17033, USA

* Corresponding author. Penn State Milton S. Hershey Medical Center, H154, 500 University Drive, Hershey, PA 17033.

E-mail address: msilvis@hmc.psu.edu

increased significantly over the past 4 decades.⁴ Running is a particularly popular choice for many, because it can be performed virtually anywhere without special equipment. Cycling has long been a common pastime and is increasing in popularity for numerous reasons, including not only its exercise benefits but also as a less expensive and greener mode of transportation.

The American College of Sports Medicine recommends that all healthy adults 18 to 65 years of age participate in moderate-intensity aerobic (endurance) physical activity for a minimum of 30 minutes on 5 days each week or vigorous-intensity aerobic physical activity for a minimum of 20 minutes on 3 days each week.⁴ These recommendations are similar for adults older than 65 years, but intensity should take into account aerobic fitness level. Flexibility and balance exercises are also recommended for older adults.⁵

As more individuals participate in running-related and cycling-related activities, physicians must be increasingly aware of the common injuries encountered in these pursuits. This review focuses on the evaluation and management of common running-related and biking-related injuries.

RUNNING

Introduction

In the United States, in the past, running was mostly considered an elite, fringe sporting activity for competitive men.⁶ In the late 1960s to the 1970s, 3 historical events brought running into mainstream American life.⁷ Dr Kenneth Cooper's 1968 book, *Aerobics*,⁸ advanced the theory of how people could most efficiently reach high levels of physical fitness based on his work with the US Air Force. In 1972, American Frank Shorter won the Olympic gold medal in marathon in Munich. In 1977, Jim Fixx published *The Complete Book of Running*,⁹ the first self-help guide for individuals beginning a running program; it became a bestseller. The 1970s running boom that followed has yet to plateau. There were more than 13 million road race finishers in 2010 in the United States.¹⁰

The benefits of running are numerous and include lower risks of early death, coronary artery disease, cerebrovascular disease, hypertension, adverse lipid profile, type 2 diabetes mellitus, metabolic syndrome, colon cancer, and breast cancer. Other benefits include prevention of weight gain, acceleration of weight loss, prevention of falls, and reduced risk of depression.¹¹ Vigorous exercise in middle and older ages has been associated with reduced disability in later life and notable survival advantage.¹²

Running can be hazardous. Between 37% and 56% of recreational runners sustain running-related injuries each year.¹³ Most injuries are caused by overuse. The onset is insidious, with no specific traumatic event. Risk factors for running-related injury fall into 4 broad categories (**Box 1**).⁵

Known predictors of lower extremity running injury include running more than 64.4 km (40 miles) per week and history of previous lower extremity injury.^{14–16} A

Box 1

Risk factors for running-related injury

Systemic	Gender, weight, knee alignment, arch type, flexibility
Running/training related	Training frequency, alterations, terrain, race distance, running experience, shoe age, pace
Health	Previous injuries, medical problems
Lifestyle	Alcohol, tobacco, cross-training

recent systematic review found that most leg injuries in runners were caused by knee pain, lower leg pain, foot pain, or thigh pain.¹⁷ The differential diagnosis for leg pain in a runner is broad (Table 1).¹⁸ In a study of more than 2000 running-related injuries,¹⁹ the most common leg injuries included the following:

- Medial tibial stress syndrome (MTSS)
- Achilles tendinopathy
- Tibial stress fractures

Evaluation

History

Evaluation of an injured runner should include details such as location, duration, onset, course, quality, and intensity of symptoms. Asking a runner when they experience symptoms is also a critical part of the assessment: at rest or during or after the run. Previous treatments should be explored as well as exacerbating or relieving factors.

Training errors lead to most running injuries. “Too much, too far, and too often” is often to blame. Asking questions in regard to weekly running mileage, changes in duration/intensity of training, changes in the type of running surface, surface grade, age of footwear, and recent changes in gait, footwear, or orthotics can often help to determine the underlying cause for the injury.

Physical examination

Physical examination of the injured runner should include a detailed examination of the injured area. However, the examination must reach beyond the site of injury. Most runners arrive in clinic already knowing their diagnosis from previous experiences or from reading running magazines/Web sites. The more important and difficult aspect of the examination is determining what potential biomechanical factors may have led to the injury.²⁰

Examination typically begins with a screening gait evaluation and then observing the injured runner while standing, sitting, lying supine, lying prone, and lying on 1 side. A thorough site-specific examination is performed on the injured region.²⁰

Gait analysis

A runner’s gait can be evaluated in several ways. Observational gait analysis (eg, patient walking in a hallway) can provide useful information. However, multiplanar videotape observational gait analysis, when available, provides the truest picture of

Body System	Possible Specific Diagnoses
Skeletal	Medial tibial stress syndrome, stress fracture
Musculotendinous	Tendinopathy, myopathy
Vascular	Exertional compartment syndrome, venous thrombosis, popliteal artery entrapment syndrome, claudication
Neurologic	Nerve entrapment, lumbosacral radiculopathy, neurogenic claudication
Infectious	
Neoplastic	

Data from Gallo R, Plakke M, Silvis M. Common leg injuries of long-distance runners: anatomical and biomechanical approach. *Sports Health* 2012;4(6):485–95.

running form.²⁰ Although gait analysis may help identify underlying biomechanical abnormalities, it is not clear whether correction of these factors helps prevent or treat running injuries.

In developed countries, most runners wear running shoes and heel strike. In its simplest form, running gait begins with lateral heel strike, followed by foot pronation during midstance and foot supination during liftoff.^{21,22} Proper gait is critical for a runner to absorb the impact of foot strike, because ground reaction forces can reach 1.5 to 3 times the runner's weight.²³ The rear foot strike pattern of most runners is aided by the elevated and cushioned heels of modern running shoes. Modern running shoes are typically recommended based on arch and foot type, but although these shoes are popular, recent studies have not found this approach to be successful in reducing injury rates.^{24–27}

Recently, biomechanical research and popular books such as *Born to Run*²⁸ have led to an interest in barefoot running.^{29–31} Barefoot runners land on the forefoot or mid-foot instead of the heel, resulting in smaller impact forces on foot strike. No clinical studies have shown that this running style reduces risk of injury.^{29,30}

Imaging and additional testing

History and physical examination are often adequate for proper diagnosis and management of running-related injuries. However, imaging can sometimes help assist in differentiating among diagnoses with similar clinical presentations or to determine degree of injury.³² Imaging modalities and ancillary tests are discussed later in this review in regard to specific running-related injuries.

BIKING

Introduction

Participation in cycling is increasing across the United States, especially among those seeking a low-impact alternative to running and other aerobic activities. Although road cycling decreased slightly in 2010, there were significant increases in BMX bicycling, mountain biking, and triathlon participation when compared with previous years. Adults older than 25 years averaged 50.5 outings per year, whereas youth aged 6 to 24 years averaged 66.7 outings per year, for a total of 2.4 billion bike outings combined.³³

Benefits of cycling are similar to those of running or other forms of cardioaerobic exercise.

Cycling-related injuries are also increasing as more people participate. Most reported cycling injuries are related to overuse,³⁴ with gradual onset and without specific traumatic event, because of the repetitive nature of the activity.^{35,36} If most cyclists average between 50 and 120 revolutions/min, that translates into 3000 to more than 7000 revolutions in 1 hour. In addition to overuse, important contributors to cycling injury are improper bike fit and improper technique/training.³⁷ The most common sites for nontraumatic cycling-related injuries include the knee, leg, hand/wrist, neck/shoulder, back, and perineum.^{35,38,39}

Prevention

Bicycle safety helmet use has been associated with decreased risk of head, brain, facial, and fatal injury,⁴⁰ and legislation requiring helmet use in children has also been associated with lower rates of injury.⁴¹ Correct ergonomics, including bike fit and equipment, and training/technique should be emphasized, and errors in these areas should be corrected.^{34–36,39}

Evaluation

History

The history is crucial in evaluating the injured cyclist; as in much of medicine, the history helps guide additional evaluation and approach to therapy. Clinicians should enquire about recent changes in riding position, equipment (saddle, handlebars, shoes, cleats), and training (schedule, distance, terrain).^{34,36} Evaluation of an injured cyclist should include details such as location, duration, onset, course, quality, and intensity of pain. Previous treatments should be explored as well as exacerbating and relieving factors.

Physical examination

Physical examination of the injured cyclist should begin with a detailed examination of the injured area. However, the examination must reach beyond the site of injury. The more important and difficult aspect of the examination is determining what potential biomechanical factors may have led to the injury, including the role of the cyclist's bike fit.

Road bicycle fit

Specific adjustments (**Table 2**) may resolve a patient's symptoms in many cases or prevent their recurrence after an appropriate period of rest. Among the most helpful tools in addressing underlying factors leading to nontraumatic cycling injuries is observation of the cyclist on their bike using a trainer stand, although this may be beyond the scope of most primary care physicians. Silberman and colleagues³⁵ have published a concise illustrated guide to road bicycle fitting.

Imaging and additional testing

History and physical examination are often adequate for proper diagnosis and management of cycling-related injuries, similar to injured runners. Likewise, imaging can be helpful in assisting in differentiating among diagnoses with similar clinical presentations or in determining degree of injury.

SPECIFIC ORTHOPEDIC CONDITIONS ENCOUNTERED IN RUNNING AND/OR BIKING, PRESENTED ALPHABETICALLY

Achilles Tendinopathy (Running, Biking)

Introduction

Achilles tendinopathy is common in runners, with an incidence of approximately 10%,⁴² and may occur in cyclists as well, although less frequently. Diagnosis is based on the history and physical examination. Imaging is used to exclude other causes and to confirm an Achilles rupture.

Cause

Achilles disorders are especially common in middle-aged athletes.³⁴ During running, the Achilles tendon experiences loading 12.5 times body weight.¹⁸ Achilles tendinopathy is affected by both intrinsic and extrinsic risk factors (**Box 2**).^{18,35,43}

Clinical presentation

Achilles tendinopathy presents as gradual pain of insidious onset. Patients with milder injury experience mild pain during exercise only, whereas more severe cases can affect normal daily activities. Acute injury with the sudden sensation of being struck in the back of the heel suggests Achilles rupture.

Physical examination

Achilles tendinopathy is suggested by tenderness to palpation 2 to 6 cm proximal to the tendon insertion over the posterior calcaneus. Tendon thickening and presence of

Table 2	
Location of symptoms and suggested bicycle adjustments in cyclists with pain or numbness	
Location of Symptoms	Suggested Adjustment(s)
Neck or scapula	Adopt more upright riding position Raise stem (handlebar) height Shorten stem length Ride with hands on upper handlebar position or on top of handlebars
Hand(s), especially ulnar	Use padded gloves Add/increase handlebar padding Change hand position every few minutes Raise stem height Move saddle backward Level saddle if tilted down
Low back pain	Adopt more upright riding position Raise stem height Shorten stem length
Shin	Lower saddle height
Heel	Adjust saddle height (may be too high or too low)
Foot	Move cleat back (or more rarely forward) Check sole for wear Check for inward cleat bolt pressure Use wider shoes Loosen shoe straps/buckles
Perineum	Lower saddle height Reduce saddle tilt Use saddle with cutaway midline section (for men) Use wider saddle (especially for women)
Knee, anterior	Raise saddle height Move saddle backward Reduce climbing Increase cadence, decrease resistance (use smaller gears) Shorten cranks
Knee, medial	Reduce outward toe-pointing Reduce tension needed to exit clipless shoe-pedal system Ride with feet closer together
Knee, lateral	Reduce inward toe-pointing Ride with feet further apart
Knee, posterior	Lower saddle height Move saddle forward

Data from Silberman MR, Webner D, Collina S, et al. Road bicycle fit. *Clin J Sport Med* 2005;15(4):271–76; and Wanich T, Hodgkins C, Columbier JA, et al. Cycling injuries of the lower extremity. *J Am Acad Orthop Surg* 2007;15(12):748–56.

a nodule may be noted. Crepitus over the tendon suggests acute tenosynovitis. The Thompson test should be performed if Achilles rupture is suspected; loss of passive ankle plantar-flexion with a calf squeeze is a positive test.

Treatment

Relative rest, ice, and nonsteroidal antiinflammatory drugs (NSAIDs) reduce pain from inflammation in the acute phase. Physical therapy and heel lifts can help correct underlying biomechanical abnormalities predisposing to this injury. Running and biking are usually avoided during the acute phase. Light loading of the Achilles tendon

Box 2	
Intrinsic and extrinsic risk factors affecting Achilles tendinopathy	
Intrinsic Risk Factors	Extrinsic Risk Factors
<ul style="list-style-type: none"> • Regional hypovascularity • Endocrine/metabolic disorders • Genetic factors 	<ul style="list-style-type: none"> • Overuse • Poor flexibility • Training errors • Excessive lateral heel strike • Hip muscle weakness • Cycling position • Incorrect bike fit

is recommended after the acute phase while the tendon is remodeling.¹⁸ Raising saddle height may reduce symptoms for cyclists,^{43,44} as may properly aligning an incorrectly rotated foot, or placing the foot further forward on the pedal.⁴³ Eccentric calf strength training has been shown to help runners with Achilles tendinopathy and forms the cornerstone of treatment.⁴⁵ Shock wave therapy is an unproven treatment, corticosteroid injections should be avoided, and other injections (eg, platelet-rich plasma injections) are considered experimental. Although several surgical techniques are described for persistent Achilles tendinopathy, most injuries resolve with conservative care, and operative management is therefore rarely necessary.¹⁸

Chronic Exertional Compartment Syndrome (Running, Biking)

Introduction

Chronic exertional compartment syndrome (CECS) is a common complaint, reported in 22% to 33% of runners with leg pain,^{46,47} and is often overlooked as a source of pain in cyclists.⁴³ There are 4 compartments in the leg, with specific structures enclosed within each defined space (**Box 3**).⁴⁸

Cause

CECS results from increased pressure, resulting in reversible ischemia within a closed fibro-osseous space.^{43,48} This situation leads to decreased blood flow, with resultant ischemic pain. Although multiple predisposing factors have been investigated, data are limited on specific risk factors.¹⁸

Clinical presentation

Runners with CECS typically report recurrent pain that occurs at a well-defined point during running and that quickly disappears with cessation of running. Cyclists experience pain from shortly after the start of a ride until several minutes after its end. The pain is commonly described as a dull ache or burning sensation over the involved compartment. Symptoms are bilateral in most athletes. The length of the rest period required before resolution of symptoms increases over time with continued exercise, resulting in consultation.

Physical examination

CECS is diagnosed best by history, because physical examination findings are frequently normal at rest. After an exercise challenge, the involved compartment(s)

Box 3	
Specific structures enclosed within compartments in the leg	
Anterior (45% of cases)	<ul style="list-style-type: none"> • Tibialis anterior muscle • Extensor hallucis longus muscle • Extensor digitorum longus muscle • Peroneus tertius muscle • Deep peroneal nerve • Anterior tibial artery and vein
Posterior, deep (40%)	<ul style="list-style-type: none"> • Tibialis posterior muscle • Flexor hallucis longus muscle • Flexor digitorum longus muscle • Posterior tibial nerve • Posterior tibial artery and vein
Posterior, superficial (5%)	<ul style="list-style-type: none"> • Gastrocnemius muscle • Soleus muscle • Sural nerve
Lateral (10%)	<ul style="list-style-type: none"> • Peroneus longus muscle • Peroneus brevis muscle • Superficial peroneal nerve

may become tender and swollen. Occasionally, a soft tissue bulge occurs with muscle contraction, representing muscle herniation.

Compartment pressure testing is used by sports medicine specialists to confirm the diagnosis of CECS.^{49,50} Near-infrared spectroscopy and magnetic resonance imaging (MRI) are being studied as alternative, noninvasive methods of measuring intracompartmental pressures.⁴⁸

Treatment

Conservative treatment is typically attempted for 6 to 12 weeks. Conservative measures include reduction/cessation of running, NSAIDs, stretching, and orthotics. A recent study reported on successful treatment of anterior compartment syndrome with alteration of running gait to barefoot running.⁵¹

For most runners who wish to continue running, definitive treatment is surgical. Subcutaneous fasciotomy of the involved compartment(s) provides effective, long-lasting relief of symptoms.

Iliotibial Band Syndrome (Running, Biking)

Introduction

Iliotibial band syndrome (ITBS) is the most common lateral knee injury in runners, with an incidence between 5% and 14%,⁵² and is common in cyclists as well. The iliotibial (IT) band is a confluence of proximal fascia of the hip flexors, extensors, and abductors. It originates at the lateral iliac crest and extends distally to the patella, tibia, and biceps femoris tendon.

Cause

Several suggested causes include friction of the IT band against the lateral femoral epicondyle, compression of the fat and connective tissue deep to the IT band, and chronic inflammation of the IT band bursa.⁵³ Although likely multifactorial, associated factors include excessive mileage, sudden increase in mileage, little running experience, leg length discrepancy, genu varum, high arches, hip abductor weakness, banked running surfaces, and hip inflexibility.^{54,55} Diagnosis is based on the history and physical examination. Imaging is used to exclude other causes.

Clinical presentation

Diffuse lateral knee pain is the primary initial complaint, most often during running or cycling. Often pain begins several minutes into activity, or even after completion. As ITBS worsens, symptoms present earlier in exercise or even at rest. Patients may be unable to localize 1 specific area of pain but indicate pain over the entire lateral aspect of the thigh and knee. If the precipitating activity continues, the initial achiness progresses to a sharp and localized pain over the lateral femoral epicondyle or lateral tibial tubercle. Lateral knee snapping is also a common complaint in runners with ITBS. Running down hills often worsens the pain, as does sitting for extended periods with the knee in flexion.^{52,53}

Physical examination

Patients often have lateral knee tenderness to palpation 2 cm above the joint line. Tenderness is often more pronounced when the patient is standing with the knee flexed at 30°. Patients may have weakness in the knee extensors, knee flexors, and hip abductors. The Ober test can be used to assess tightness of the IT band. The patient is asked to lie on the unaffected side, with the unaffected hip and knee both flexed at 90°. While stabilizing the pelvis, the affected leg is abducted and extended until aligned with the rest of the body. The affected leg is then lowered into adduction. If there is tightness of the IT band, the leg remains abducted and the patient experiences lateral knee pain.⁵²

Treatment

Prognosis for ITBS is generally good. The initial goal of treatment is to reduce inflammation. NSAIDs and ice may be used. Patients should avoid activities that require repeated knee flexion and extension. The triggering activity is typically discontinued until symptoms improve. A stretching and strengthening regimen focused on the IT band should then be prescribed; physical therapy can be helpful. IT band flexibility can be increased by overhand arm extension while performing a standing IT band stretch.⁵⁵ Foam roll bars are commonly recommended to improve IT band flexibility.

When a runner can resume strength exercises without pain, running can be resumed at a gradual pace on a level surface and slowly increased over 3 to 6 weeks. Addressing underlying biomechanical conditions or training errors reduces risk of recurrence.

Cyclists may find relief from adjusting cycling position, saddle height, or their pedal/cleat system.³⁴

Rarely, corticosteroids or surgery may be indicated if patients do not respond to conservative management.^{52,53}

MTSS (Running)**Introduction**

MTSS is defined as exercise-related leg pain over the mid to distal posteromedial tibia. With an incidence of 4% to 33% in military personnel and athletes,⁵⁶ MTSS commonly affects runners.

Cause

Numerous theories relate functional anatomy and pathologic biomechanics to MTSS. Historically, periosteal inflammation has been attributed to MTSS caused by abnormal traction of the calf muscles (eg, soleus),⁵⁷ but recent histologic reviews contradict this theory. Mismatch between bone formation and resorption causing overloading of the tibial cortex is the most likely cause.⁵⁶ MTSS is associated with the following risk factors^{18,56}:

- Imbalance of foot pressure
- Excessive pronation
- Female sex
- Higher body mass index
- Previous MTSS
- Sudden increases in training intensity and duration
- Uneven running surfaces

Clinical presentation

Runners with mild MTSS typically describe mid to distal posteromedial tibial pain, which begins with initiation of running and which subsides with continued exercise. Severe MTSS is present throughout exercise and at rest and should heighten suspicion for stress fracture.

Physical examination

Accurate location of symptoms, risk factor evaluation, and elimination of other conditions associated with leg pain in runners form the basis of the physical examination. Diffuse tenderness to palpation over the mid to distal posteromedial tibia is the most sensitive finding.⁵⁸ Focal tenderness should heighten suspicion for stress fracture. The diagnosis of MTSS is clinical. Imaging should be obtained if the diagnosis is unclear.

Treatment

MTSS is treated with activity modification, stretching, ice, and NSAIDs. Calf muscle strengthening, antipronation insoles, massage, aerobic fitness, electrotherapy, and acupuncture are commonly recommended, but randomized controlled trials and case series supporting their use are lacking.⁵⁶

Patellofemoral Pain Syndrome (Running, Biking)

Introduction

As discussed earlier, most injuries during running and cycling lead to knee pain, and patellofemoral pain syndrome is responsible for nearly 25% of injuries to the knee.⁵⁹ The patella articulates with the patellofemoral groove in the femur. As the patella moves up and down, tilts, and rotates, there are numerous points of contact between its undersurface and the femur.

Cause

Although the cause of patellofemoral pain syndrome is not fully understood, it is most commonly hypothesized that increased stress on the patellofemoral joint leads to wear of the articular cartilage.⁵⁹ Possible predisposing factors include anatomic variations that precipitate patellar malalignment and instability, lower extremity malalignment from foot hyperpronation or other causes, and imbalances in muscle and soft tissue (eg, between the medial and lateral quadriceps muscles).

Clinical presentation

Patients present with anterior knee pain, which can have insidious onset, typically occurring with exercise, and worsening when squatting, descending steps or hills,

or after prolonged sitting.^{34,59,60} Pain is usually achy, sometimes sharp, and may occur in 1 or both knees. Gross effusions are rare, but mild swelling may be present. There may be perceived instability, which should be distinguished from instability caused by patellar dislocation, subluxation, or ligamentous injury of the knee.

Physical examination

Inspection may reveal vastus medialis oblique muscle atrophy or abnormalities in alignment such as the J sign (curvilinear lateral tracking of the patella with quadriceps contraction) or a Q angle, caused by excessive lateral insertion of the patellar tendon. Despite abnormal patellar tracking, there should be no decrease in range of motion. Crepitus is common with active extension. Tenderness is common along the femoral condyles and patellar facets, as is tenderness behind the patella with light patellar compression. It is important to consider radiography with a history of trauma or dislocation or with lack of improvement after several weeks of conservative therapy.

Treatment

The first stage of a comprehensive treatment plan is symptom control. This goal may be achieved through activity modification, NSAIDs, ice, and patellar taping or bracing with a rubber sleeve with a patellar hole. Total inactivity should be avoided, because it promotes deconditioning, which may increase susceptibility to stress injury when resuming normal activity. Cyclists may benefit from adjusting their cycling position, saddle height, or pedal/cleat system. Physical therapy is often helpful and should focus on quadriceps strengthening and correction of any issues of hip and ankle strength and control. Proprioceptive control training can be helpful as well, especially in patients with alignment issues and excessive laxity. Most athletes respond to nonoperative treatment.

Plantar Fasciitis (Running, Biking)

Introduction

Plantar fasciitis is common, with between 1 and 2 million people in the United States affected each year, and is the most common cause of plantar heel pain.^{61,62} Plantar fasciitis affects both active and sedentary populations, with peak incidence between 40 and 60 years of age.⁶² Most patients seek care from their primary care provider. Plantar fasciitis diagnosis is based on the history and physical examination.

Cause

Plantar fasciitis is now believed to be a degenerative process, rather than an acute inflammatory process. It likely results from repetitive microscopic trauma at the origin of the plantar fascia. Prolonged standing or running can contribute to the biomechanical overuse associated with plantar fasciitis.^{61,62} Incorrect saddle height may be contributory in cyclists.⁴⁴ Heel spurs can occur with plantar fasciitis, but they are not the cause. Risk factors include excessive running, obesity, and prolonged standing. Excessive foot pronation can contribute as well.

Clinical presentation

Patients report posterior heel pain, which developed gradually. It is usually worst with the first step in the morning or after prolonged sitting. The pain usually improves gradually with activity, but may be worse at the end of the day if the patient continues to walk or stand for extended periods.⁶² Walking barefoot, on toes, or up stairs may increase pain.⁶³ Plantar fasciitis pain does not often radiate and is not associated with nerve paresthesias. Constant pain or pain that wakes the patient from sleep should prompt evaluation for other causes.⁶²

Physical examination

The foot and ankle should be inspected with the patient standing and walking. Pes planus (flat foot) or pes cavus (high arch) foot deformity may be present, because these can increase loading of the plantar fascia. There is often tenderness with passive dorsiflexion, as well as tenderness to palpation over the medial plantar calcaneal tuberosity at the origin of the plantar fascia, although tenderness anywhere along the plantar fascia may be present.⁶²

Treatment

Most cases of plantar fasciitis respond to nonsurgical modalities, with response most often within 1 year, regardless of treatment; conservative therapy has been reported to be successful in up to 90% of cases.⁶¹ Patients should be counseled that pain may often persist for 6 to 12 months before resolving. Relative rest, ice, massage, and NSAIDs are common initial recommendations. Prefabricated foot orthotics can be used, as can night splints, which stretch the plantar fascia during sleep.^{34,61–63} Progressive plantar fascia and intrinsic foot muscle stretching techniques have been shown to reduce plantar fasciitis pain and should be performed multiple times daily; these are more effective than calf stretching.⁶³ Helpful adjustments for cyclists may include raising saddle height, increasing cadence, and decreasing resistance.⁴³ Corticosteroid injections can be used, and if symptoms persist longer than expected despite these measures, extracorporeal shock wave therapy or plantar fasciotomy may be considered.⁶¹

Pudendal (Bicycle Seat) Neuropathy (Biking)

Introduction

Although rarer among cyclists compared with upper or lower extremity symptoms, pelvic/pudendal symptoms can occur. Because they are less common, they may be less suspect and therefore more difficult to link initially to the cycling activity.

Cause

Symptoms may arise from pudendal nerve compression between the saddle and the pubic symphysis, or from cavernous nerve compression.⁴⁴ This situation may be caused by a saddle position that is too high or excessively tilted (either up or down). In addition, the saddle may not be wide enough to support the ischial tuberosities.³⁵

Clinical presentation

Male and female patients may present with perineal numbness and tingling. Men may experience these in the penis or scrotum, and impotence may be present, although this is less common.⁴⁴

Physical examination

Decreased sensation in the affected area helps confirm the diagnosis. Inspection may yield additional clues, such as skin irritation or calluses.⁴⁴

Treatment

Affected cyclists should not resume cycling until symptoms resolve, which generally occurs within 1 week but may take several months.⁴⁴ Lowering saddle height and reducing saddle tilt may help prevent recurrence, as may switching to a wider saddle³⁵ or, for men, a saddle with an open midline section.⁴⁴

Stress Fractures (Running)

Introduction

Stress fractures are common in runners. They are categorized as low or high risk based on healing potential (**Box 4**).

Box 4 Low-risk and high-risk stress fractures in runners	
Low Risk	High Risk
<ul style="list-style-type: none"> • Sacrum • Pubic ramus • Femoral shaft • Tibia (except anterior) • Fibula • Metatarsal shaft 	<ul style="list-style-type: none"> • Femoral neck • Anterior tibia • Medial malleolus • Navicular • Proximal fifth metatarsal • Sesamoids

Tibial stress fractures are the most common fractures in runners, accounting for 50% of stress fractures.⁶⁴

Cause

Ordinarily, bone remodels to match demands, but if bone is under repetitive stress and deprived of sufficient time to remodel, stress fractures can result. Most stress fractures occur in cortical bone and result from fatigue; cortical bone is found in the diaphysis of long bones and the shell of square bones. When the active remodeling of cancellous bone is limited, such as with the female athlete triad, metabolic bone disease, or osteoporosis, it becomes susceptible to insufficiency fractures.⁶⁵ Risk factors for stress fracture are shown in **Box 5**.^{18,66}

Clinical presentation

Runners with stress fractures commonly present with localized pain of insidious onset. Patients often report increasing amounts of pain earlier in their runs and occasionally during activities of daily living.

Physical examination

The hallmark of the examination is focal bone tenderness. Swelling, erythema, or warmth may be evident over the stress fracture. Biomechanical factors that may

Box 5 Risk factors for stress fractures	
Intrinsic Risk Factors	Extrinsic Risk Factors
<ul style="list-style-type: none"> • Poor preparticipation conditioning • Female gender • Menstrual imbalance • Decreased bone mineral density • Genu valgus/varum • Leg length discrepancy 	<ul style="list-style-type: none"> • Rapid increase in training program • High weekly training mileage • Irregular or angled surface • Poor footwear • Running shoes >6 months old • Low fat diet • Decreased calcium and vitamin D intake • Tobacco use

predispose to stress fracture should be noted, including muscle imbalances, leg length discrepancy, extreme foot types (high longitudinal arch or excessive forefoot varus), genu valgus/varum, and femoral anteversion.^{64,67,68} Imaging is used in times of uncertainty or when counseling a runner who desires ongoing training. Radiographs have low sensitivity during the first 2 to 3 weeks. Periosteal bone formation and callus formation can be detected on radiographs. Bone scans are used less frequently because of radiation exposure, time constraints, and lack of specificity. MRI may be helpful in grading stress fractures and providing prognostic information, but false-positive results can occur.⁶⁹

Treatment

Low-risk stress fractures have adequate vascularity and less strain than high-risk stress fractures. Activity modification and relative rest are frequently recommended. The runner must be pain free with ambulation before advancement. If pain occurs with walking, crutches or non-weight bearing may be indicated until pain free. Non-weight-bearing activities can be continued in most runners to preserve some conditioning, including biking, swimming, aqua running, and upper body cross-training. Once asymptomatic, runners can begin a slow transition back to running, beginning at 50% duration and intensity, increasing no more than 10% weekly. In our experience, healing commonly takes 4 to 8 weeks.

High-risk stress fractures require strict immobilization, non-weight bearing, and consideration for early surgical intervention (especially for tension-sided stress fractures). Sports medicine referral should be considered for all high-risk stress fractures.

Ulnar Compression Neuropathy (Cyclist's Palsy) (Biking)

Introduction

Ulnar compression symptoms are the most common upper extremity complaint in cyclists, occurring significantly more frequently than median nerve symptoms. There may be sensory involvement, motor involvement, or both.

Cause

Excessive and sustained pressure on the handlebars, with more of the force on the lateral (ulnar) aspect of the hand, compresses the ulnar tunnel and the ulnar nerve within it. The addition of vibration (eg, with riding on uneven or rough surfaces) may exacerbate symptoms. The more superficial location of the ulnar tunnel makes these symptoms significantly more common among cyclists than symptoms of compression from the deeper median nerve.³⁹ Lower hand positions increase pressure on the handlebars, whether related to drop-style handlebars, a stem too short or too low, or a saddle positioned too far forward or tilted downward.³⁵

Clinical presentation

Patients typically complain of paresthesias of the fourth and fifth fingers, and may experience weakness of the hand as well. Symptoms may be progressive over the course of a sustained training program, or they may begin acutely, most often after a prolonged ride.³⁹ A careful history should include type of handlebars, preferred hand location, seating position, type of terrain, and the use of any gloves or padding.

Physical examination

On inspection, atrophy of the hypothenar eminence is consistent with motor involvement. Sensory assessment should include the hypothenar eminence and both the palmar and volar aspects of the fourth and fifth fingers. Motor assessment should

focus on identifying areas of hand weakness, especially finger adduction and abduction, and thumb adduction.⁴⁴

Treatment

Most symptoms resolve promptly on cessation of the compressive activity, although they sometimes persist for months. Suggestions to alleviate symptoms and prevent recurrence include:^{35,39,44}

- Addition of handlebar padding
- Use of padded cycling gloves
- Raising handlebars
- Changing hand position frequently
- Adopting a more upright cycling position
- Leveling seat if tilted forward
- Repositioning saddle if too far forward

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