

[Athletic Training]



Chronic Lower Leg Pain in Athletes: A Guide for the Differential Diagnosis, Evaluation, and Treatment

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Context: Chronic lower leg pain in athletes can be a frustrating problem for patients and a difficult diagnosis for clinicians. Myriad approaches have been suggested to evaluate these conditions. With the continued evolution of diagnostic studies, evidence-based guidance for a standard approach is unfortunately sparse.

Evidence Acquisition: PubMed was searched from January 1980 to May 2011 to identify publications regarding chronic lower leg pain in athletes (excluding conditions related to the foot), including differential diagnosis, clinical presentation, physical examination, history, diagnostic workup, and treatment.

Results: Leg pain in athletes can be caused by many conditions, with the most frequent being medial tibial stress syndrome; chronic exertional compartment syndrome, stress fracture, nerve entrapment, and popliteal artery entrapment syndrome are also considerations. Conservative management is the mainstay of care for the majority of causes of chronic lower leg pain; however, surgical intervention may be necessary.

Conclusion: Chronic lower extremity pain in athletes includes a wide differential and can pose diagnostic dilemmas for clinicians.

Keywords: chronic leg pain; medial tibial stress syndrome; chronic exertional compartment syndrome; nerve entrapment; popliteal artery entrapment syndrome

Chronic leg pain is a common condition in competitive and recreational athletes, and the onset is frequently insidious. The causes of lower leg pain are numerous, with diagnoses varying in frequency and severity, making the differential relatively broad. Moreover, symptoms are often ambiguous, necessitating a thorough knowledge of anatomy and biomechanics of the lower extremity.¹⁶

Second only to the knee, the lower leg accounts for approximately one-third of running injuries in long-distance runners.^{35,37}

DIFFERENTIAL DIAGNOSIS

There is a wide range of diagnoses for exercise-induced leg pain in the weightbearing athlete: medial tibial stress syndrome (MTSS), chronic exertional compartment syndrome (CECS), stress fracture, nerve entrapment, and popliteal artery entrapment syndrome (PAES) are the most common (Table 1).^{16,19}

Studies show that MTSS accounts for 6% to 16% of all running injuries; it can represent up to 50% of lower leg injuries in

select populations, such as military personnel.^{33,63} CECS may be difficult to diagnose, but it is most common in runners in the anterior and lateral compartments.¹⁴ In a retrospective review of 150 athletes with exercise-induced leg pain, 33% were diagnosed with CECS, 25% with stress fractures, 13% with MTSS, and 10% with nerve entrapment syndromes.¹⁶

Medial Tibial Stress Syndrome

MTSS (shin splints) is a repetitive-stress overuse injury commonly affecting weightbearing athletes. Several intrinsic risk factors for MTSS have been identified: hyperpronation, body mass index, female sex, hip internal/external rotation, and hyperplantarflexion.^{15,29,48,63} In a prospective study of 35 male participants recruited from 2 Dutch Army bases, Moen et al found that increased hip internal rotation, increased plantar flexion, and a positive navicular drop (assessing pronation) were associated with MTSS, while a higher body mass index was associated with a longer duration to full recovery.⁴¹

The cause may be periostitis of the tibia due to tibial strain, but more recent evidence points toward a spectrum of tibial

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Table 1. Differential diagnosis of chronic lower leg pain in athletes.^{14,19}

Vascular	Popliteal artery entrapment syndrome Endofibrotic disease (primarily external iliac artery) Popliteal artery aneurysm Cystic adventitial disease Peripheral arterial dissection Intermittent claudication Deep vein thrombosis
Bone/periosteum	Stress fracture (tibia, fibula) Medial tibial stress syndrome Metabolic bone disease
Muscle/tendon	Muscle strains Tendinopathy Chronic exertional compartment syndrome
Nerve entrapment	Peripheral neuropathies Lumbar radiculopathy
Infection	Osteomyelitis
Malignancy	Muscle or bone neoplasm

stress injuries contributing to MTSS: periostitis, tendinopathy, and stress reaction of the tibia, as well as dysfunction of the tibialis posterior, tibialis anterior, and soleus muscles.^{3,8,17,23} In a cadaveric study, traction-induced muscle injury theories of the superficial and deep posterior compartments were not supported by anatomic evidence; the mean distal muscle attachments to the medial tibial border were superior to the distal third of the tibia in the posterior compartments. In contrast, the deep crural fascia of all but 3 of 16 specimens attached along the entire length of the medial tibia.⁵⁴ MTSS and tibial stress fractures may be a continuum of bone stress reactions.^{8,23}

Stress Fractures

Stress fractures of the lower extremity account for up to 80% to 95% of all stress fractures, with the majority involving the tibia; they are caused by repetitive loading with resulting bony microfracture.^{8,12,33,53,55,58} Stress fractures of the anterior tibia and medial malleolus are high-risk fractures necessitating nonweightbearing, longer periods before return to play, and/or surgical treatment.¹¹

Chronic Exertional Compartment Syndrome

CECS is a condition of increased pressure in the fascial compartments (muscles and neurovascular structures bound by fascia and bone) related to exercise leads to recurrent episodes

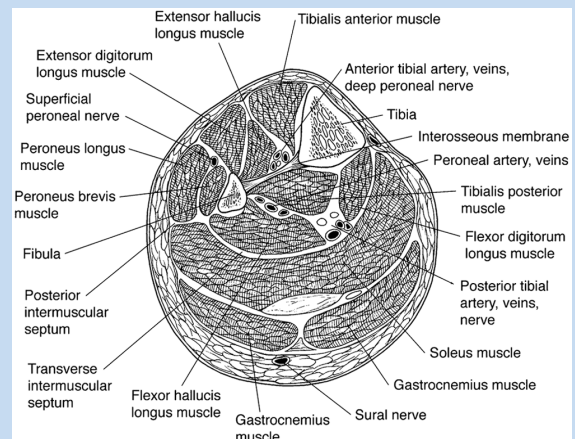


Figure 1. Cross-section of the lower left leg showing its 4 compartments: anterior at upper left; lateral at center left; deep posterior at center; superficial posterior at bottom right. Used with permission from: Fraipont MJ, Adamson GJ. Chronic exertional compartment syndrome. *J Am Acad Orthop Surg.* 2003;11:268-276.

of pain.^{10,14,62} The anterior compartment is most commonly involved (45%) with the lateral, deep, and superficial compartments less common (Figure 1).^{10,47,62} Symptoms are bilateral 85% to 95% of the time.⁵⁵ The pathophysiology of CECS is multifactorial. Factors may include constraints of a fixed muscular compartment, normal or abnormal muscle swelling that occurs with activity, abnormally thickened fascia, normal muscle hypertrophy in response to resistance training, or dynamic contraction patterns during gait.¹⁴ Low muscle capillary supply is a pathogenic factor in chronic compartment syndrome.¹⁸ Biopsies from the tibialis anterior muscle from 9 patients during fasciotomy and 1 year later revealed lower capillary density compared with controls.¹⁸

Peripheral Nerve Entrapment

The typical presentation is burning pain brought about by activity and exacerbated by continued exercise, with motor and/or sensory symptoms being regional.^{34,37} However, nerve entrapment symptoms do not always present with clear neurologic signs of motor weakness, sensory loss, or change in reflexes; diagnosis is often delayed. The common peroneal, superficial peroneal, and saphenous nerves are most commonly at risk for entrapment, with trauma being a primary cause (Figures 2-4, Table 2).^{37,51}

Popliteal Artery Entrapment Syndrome

Exercise-related arterial entrapment syndromes of the lower extremity are relatively rare, but most commonly include PAES.^{6,47} PAES is an uncommon overuse injury and is often confused with CECS and can even coexist with CECS.⁵⁶ A

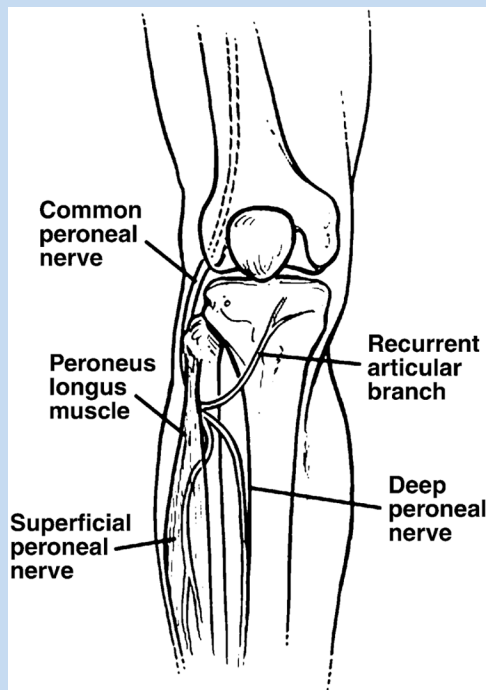


Figure 2. Drawing shows the common peroneal nerve and its branches at the knee. The common peroneal nerve wraps around the fibular neck and under the peroneus longus muscle to trifurcate into the recurrent articular branch to the knee capsule, the superficial peroneal nerve, and the dorsal peroneal nerve.

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frequent cause of PAES is compression of the popliteal artery by surrounding musculotendinous structures as it exits the popliteal fossa; the most common variant involves an accessory medial head of the gastrocnemius passing posterior to the popliteal artery.^{6,13,20} Popliteal compression can also be caused by fibrous bands of the gastrocnemius or the popliteus muscle or an aberrant course of the popliteal artery.²⁰ PAES can also be functional, with vascular testing results often normal.⁵⁶

Other potential vascular causes of lower extremity pain in athletes to consider include endofibrosis (intimal hyperplasia), popliteal artery aneurysm, cystic adventitial disease, and peripheral arterial dissections.⁴⁷

DIAGNOSIS

History

An activity history may be useful in determining if the condition is secondary to a training error. It is important to determine the number of sessions per week and the duration and intensity of each activity. An abrupt increase in these



Figure 3. Normal anatomy of the tibial, common peroneal, and saphenous nerves at the level of the knee. Axial magnetic resonance image shows the tibial nerve (white arrowhead) between the lateral head (LG) and medial head (MG) of the gastrocnemius muscle. The common peroneal nerve (black arrowhead) is seen between the lateral gastrocnemius muscle and biceps femoris muscle (B). The saphenous nerve branches (white arrow) are seen lateral to the sartorius muscle (black arrow).

Used with permission from: Donovan A, et al. MR imaging of entrapment neuropathies of the lower extremity. *Radiographics*. 2010;30:1001-1019.

variables may be a contributing factor, as well as a recent change in training surface or footwear.^{23,44,59}

Risk factors for stress fractures include female sex, white race, irregular menses, eating disorder, osteoporosis or osteopenia, and previous stress fractures.^{9,23,32}

Physical Examination

Specific examination tests for MTSS, stress fractures, CECS, and PAES can assist the clinician in narrowing the differential diagnosis and deciding if further diagnostic tests are necessary.

EVALUATION AND TESTING

MTSS: Magnetic Resonance Imaging and Bone Scan

Radiograph results are normal with MTSS. Magnetic resonance imaging (MRI) and bone scans usually show abnormally high signal along the posterior medial tibial surface or the classic train-track appearance of nucleotide uptake on a nuclear medicine bone scan.⁵ MRI demonstrates superior sensitivity and specificity in early tibial stress injuries.^{7,24}



Figure 4. Common peroneal neuropathy secondary to a ganglion of the proximal tibiofibular joint. Sagittal magnetic resonance image shows a ganglion arising from the proximal tibiofibular joint (arrow) with associated denervation-related increased signal intensity of the anterior tibial and extensor digitorum longus muscles (arrowheads).

Used with permission from: Donovan A, et al. MR imaging of entrapment neuropathies of the lower extremity. *Radiographics*. 2010;30:1001-1019.

Stress Fractures: Radiographs and MRI

Plain radiographs are usually negative for early stress fractures. The sensitivity of radiographs may be as low as 10% (Figure 5).²³ Abnormalities are usually seen after 2 to 8 weeks of symptoms.^{11,23} Bone scan is a more sensitive but less specific method in detecting stress injuries.^{26,61,64} Computed tomography can be helpful in distinguishing conditions that mimic stress fractures on bone scan, such as malignancies. It can differentiate stress fractures from stress reactions.^{23,27} MRI, however, shows edema (Figure 6), often within about 3 days of symptom onset, and is more sensitive and specific than computed tomography or bone scan for diagnosing stress fractures of the tibia.²⁴

CECS: Compartment Pressure Testing

Compartment pressure testing is the gold standard for CECS.^{30,36,45} Preexercise and postexercise measurements are needed.⁵⁶ The postexercise measurements should be taken within 5 minutes of the exercise; the athlete should be symptomatic at the time of measurement.⁴⁶ A positive compartment pressure test is a preexercise resting pressure of 15 mmHg or greater and/or a 1-minute postexercise pressure of 30 mmHg or greater and/or a 5-minute postexercise pressure of 20 mmHg or greater.⁴⁶

PAES: Ankle-Brachial Index and Angiography

Initial screening with the ankle-brachial index (ie, ratio of the blood pressure in the lower legs to the blood pressure in the arms) can be helpful before vascular studies of the lower extremity. Because this entrapment may be functional, it is recommended that the ankle-brachial index be done with the ankle in only the neutral, forced dorsiflexion, and forced plantarflexion positions. An ankle-brachial index of less than 0.9 is abnormal. The sensitivity of the ankle-brachial index is 90% and the specificity is 98% for significant stenosis of greater than 50% in major leg arteries.³⁸ Although direct angiography has been considered the gold standard, both computed tomography angiography and magnetic resonance angiography are quite useful in detecting this condition and are less invasive (Figure 7).⁴

Peripheral Nerve Entrapment: Electrodiagnostic Studies

Electromyography and nerve conduction velocities can be helpful in diagnosing nerve entrapment and the level of the lesion.³⁷ The condition must be present for at least 3 to 4 weeks for the studies to become positive.^{55,60}

TREATMENT

Medial Tibial Stress Syndrome

The treatment of MTSS has been examined in 3 randomized controlled trials, showing that rest is equal to ice, nonsteroidal anti-inflammatory drugs, proper conditioning, physical therapy for stretching and strengthening of the calf musculature, rigid orthotics to correct foot hyperpronation, and activity modification.⁴³ The use of neoprene or semirigid orthotics may help prevent MTSS.⁴³ Newer conservative measures include extracorporeal shockwave therapy, which may speed recovery.^{42,50} A pneumatic leg brace is not as effective as rehabilitation and rest.⁴⁰ Most cases of MTSS usually do not preclude participation in sports activities.²⁵

Stress Fractures

The treatment depends on the fracture risk. Fibular and posteromedial tibial stress fractures are considered low risk and can be treated conservatively with ice, pain medicine, a walking boot, cross training, and limiting impact activities. Anterior tibia or medial malleolar stress fractures are high risk and should be treated aggressively with nonweightbearing, casting, and/or bone stimulator for extended periods (3 months). In competitive athletes, internal fixation may be considered to increase healing potential and quicker return to activity.³¹ Pneumatic bracing may speed rehabilitation following tibial stress fractures.^{1,2} Preventative measures hinge on appropriate training intensity and duration for each athlete;

Table 2. Specific nerve entrapment syndromes in the lower extremity.^{16,37,55}

Nerve Entrapment Syndrome	Relevant Anatomy	Common Cause	Clinical Presentation
Saphenous nerve	Largest branch of the femoral nerve arising from L1, L2, L3; the nerve leaves the femoral triangle to enter the adductor canal with the femoral artery and vein	The nerve can be injured in the adductor canal by local trauma, infection, or inflammation; the nerve may also be injured at the knee due to arthroscopy, trauma, or pes anserine bursitis	Medial knee and/or leg pain
Common peroneal nerve	As the nerve enters the peroneal (fibular) tunnel, it divides into deep and superficial branches	Compression at the peroneal tunnel from sources such as casts, surgery, osteophytes, and cysts or by sitting in a prolonged crossed-legged position	Sensory disturbances in the lateral lower leg and foot with possible foot drop and pain at site of compression
Sural nerve	Begins with its main component from the tibial nerve in the popliteal fossa and runs distally between the 2 heads of the gastrocnemius	Compression from mass lesions, scar tissue, ganglia, surgical trauma, or extrinsic compression from casts or tight ski boots	Shooting pain in the cutaneous distribution of the nerve (lateral aspect of ankle/foot)
Superficial peroneal nerve	Travels in the lateral compartment and supplies the peroneus longus and brevis muscles; pierces the deep fascia and emerges into the subcutaneous fat at approximately 10 to 15 cm above the tip of the lateral malleolus	Local trauma or compression is the most common underlying cause; nontraumatic causes are commonly due to anatomic variations, such as fascial defects with or without muscle herniation about the lateral lower leg	Numbness or paresthesia in the distribution of the nerve or lateral leg pain; more typically present with vague pain over the dorsum of the foot; symptoms increase with activity

shock-absorbing inserts in footwear may help prevent stress fractures.⁴⁹

Chronic Exertional Compartment Syndrome

Nonsurgical measures of CECS of the lower extremity include intermittent massage with stretching, taping, orthotics, and nonsteroidal anti-inflammatory drugs.¹⁴ The only evidence-based treatment is activity modification and rest.¹⁰

The treatment of CECS that fails conservative care is typically surgical.²¹ Patients with anterior or lateral compartment symptoms tend to have better outcomes: greater than 80% success rate as compared with deep posterior CECS, which has a success rate of about 50%.^{10,28} Postoperative care includes an approximate 12-week rehabilitation starting with protection and mobility, early light strengthening, scar massage with

mobility and desensitization, progression of strengthening exercises, and concluding with impact and sport-specific training.⁵²

Popliteal Artery Entrapment Syndrome

The treatment of PAES is by surgical removal of the compressing structure and either venous bypass or interposition graft, but it may be different from case to case.⁵⁶ Endovascular revascularization followed by release of arterial compression is a feasible alternative.³⁹

Peripheral Nerve Entrapment

Conservative management—including modifying precipitating activity, biomechanical correction, physical therapy, massage,



Figure 5. Lateral plain radiograph of the tibia showing an anterolateral stress fracture. This high-risk tension-sided stress fracture may be associated with prolonged nonunion.

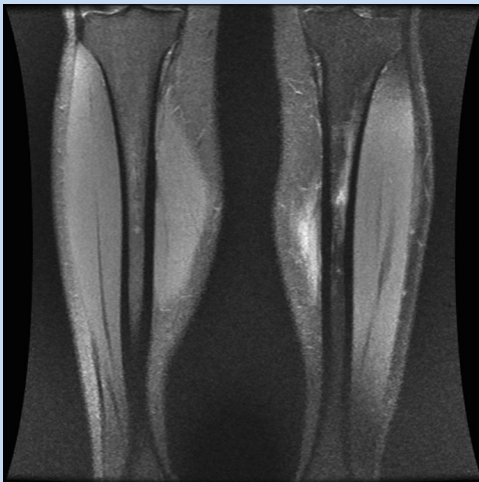


Figure 6. Coronal magnetic resonance imaging of bilateral lower extremities demonstrating an early stress reaction of the left tibia as evidenced by the development of edema in the proximal tibia.

and nonsteroidal anti-inflammatory drugs—is the mainstay of treatment for most nerve entrapment syndromes.^{34,37,51} While nonoperative management is usually successful in most nerve entrapment syndromes (common peroneal and saphenous nerve), some may require surgical intervention (superficial peroneal).^{37,51}

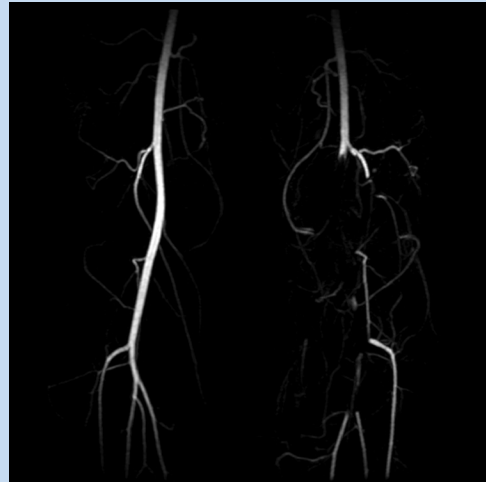


Figure 7. Magnetic resonance angiogram demonstrating occlusion of the left popliteal artery due to popliteal artery entrapment syndrome.

SUMMARY

The most common causes of chronic lower leg pain in athletes are MTSS, stress fractures, CECS, nerve entrapment syndromes, and PAES. Symptom overlap can make evaluation and treatment difficult. A thorough history and physical examination is essential. Conservative management is the initial treatment for most chronic lower leg pain. Surgical intervention may be necessary in some high-risk stress fractures, PAES, nerve entrapment syndromes, and CECS.

Treatment of stress fractures is based on risk classification. Prolonged immobilization and nonweightbearing or surgery for high-risk fractures may be indicated. Avoidance of high-impact activity for low-risk stress fractures is advised.

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