

Cover article

Shin pain in an adolescent soccer player: A case-based look at “shin splints”

By Jordan D. Metz, MD, and Joshua A. Metz



Do you care for children who regularly run or play sports—especially adolescents? Then you should have a basic understanding of the different entities that can cause shin pain. That list includes tibial stress injuries and exertional compartment syndrome.

Causes of “shin splint” pain discussed in this article

- Medial tibial stress syndrome
- Tibial stress fracture
- Peripheral neuropathy
- Lumbar radiculopathy
- Exertional compartment syndrome

A 14-year-old high school soccer player, referred by her pediatrician, has been brought to the sports medicine clinic reporting a one-year history of “shin splints.” She describes shin pain in both legs that seems to increase with running and brisk walking, mostly over the “front” of her shins. She characterizes her pain as a “tightness” that “pinches” her legs and becomes noticeable five to seven

minutes after she begins activity. The pain has become more intense the past two months—to the point where she is unable to run for more than 10 minutes at a time.

The patient denies any history of trauma or of paresthesia or radiculopathy into the feet or toes. There is no history of foot drop. In the past two weeks, she has begun to limp when the shin pain is present. After she stops running, the pain disappears in five to 10 minutes. She has no pain at night or at rest.

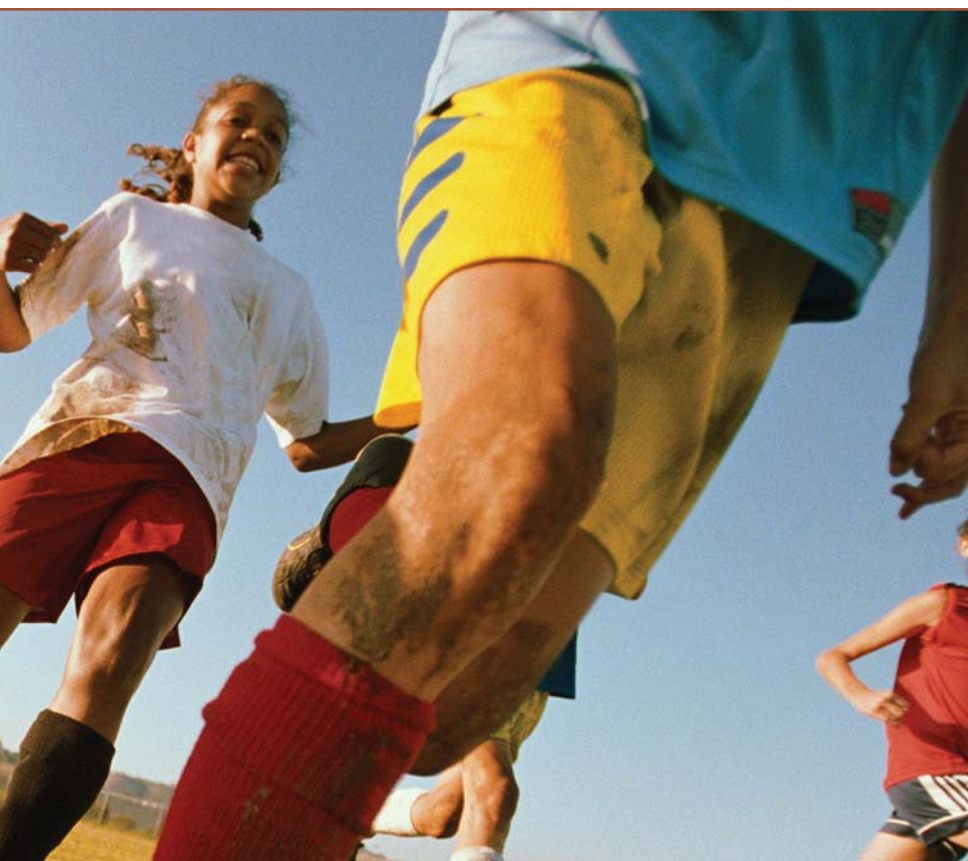
The medical history reveals mild asthma that is treated with a β -agonist medication. She has no significant orthopedic history. Her dietary history is noteworthy for inadequate calcium intake (approximately 1,000 mg/day), and her menstrual history is remarkable for onset of menses at age 13. Since that time, she has had monthly cycles. There is no family history of osteoporosis.

On physical examination, the gait is normal; there is no limp. She has moderate pronation of her feet with standing (Figure 1). She exhibits no bone tenderness in either leg upon palpation of the posterior-medial and anterior tibia (Figures 2 and 3).

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Overuse injury in bone is a spectrum—from stress injury and edema in the medullary bone without cortical involvement to stress fracture, edema in the medullary bone, point tenderness, and a fracture line through the peripheral cortical bone. Most cases of bone-related shin splints occur in the tibia and, as detailed later, fit a particular pattern. Tibial stress injury, which includes medial tibial stress syndrome (MTSS) and tibial stress fracture,^{3,4} results when the process

of bone building and resorption (remodeling) is unable to adapt to repetitive stress.

Palpation of the tibialis anterior in the anterior compartment muscles does, however, reveal tenderness (Figure 4). A hop test reveals no evidence of tenderness, meaning she has no pain when asked to hop on each leg (Figure 5). The neurosensory examination is normal.

Differential diagnosis

“Shin splints” generally refers to overuse injury to the bone or muscle in the lower leg. Remember, however, that shin splints are a symptom, not a diagnosis.¹ The term has caused confusion and controversy over the past 40 years when used to refer to a variety of exercise-induced lower-leg disorders. Given the lack of diagnostic precision, the exact incidence of exercise-induced lower leg pain in athletes is difficult to determine, but it accounts for roughly 10% to 20% of all injuries in runners and as many as 60% of all overuse injuries in the leg.^{1,2}

Overuse injuries such as shin splints are the result of repetitive force applied to otherwise normal tissue. They generally develop over weeks to months. In contrast, acute traumatic injury, such as a concussion or fracture, occurs immediately with one specific event. A common feature of overuse injuries is pain initially associated with a particular activity, such as running, swimming, or throwing a baseball, that becomes worse over time as that activity is repeated. Early diagnosis of overuse injury usually leads to a more favorable outcome than a prolonged period between presentation and diagnosis.

of bone building and resorption (remodeling) is unable to adapt to repetitive stress.

To understand specific types of bone injury, it is important to understand the way in which bone is altered. Normally, bone responds to changes in loading patterns with an increase in metabolic activity or bone remodeling known as Wolfe’s law. At a microscopic level, remodeling occurs in a well-defined pattern. When bone encounters new and sustained mechanical stress, osteoclasts remove old bone matrix, creating pores in the bony framework. Next, osteoblasts deposit new bone matrix into the pores. The rate of bone formation should equal the rate of bone resorption. Under pathologic circumstances, porous bone cannot accommodate continuous loading, resulting in microfissures that can progress to stress fracture.⁵

The other main classification of shin splint pain is related to overuse of muscle, which often goes undiagnosed for a long time because the pain takes more time to become acute and limit activity compared with bone pain. The muscular type of shin pain is known as (chronic) exertional compartment syndrome (ECS). Unlike bone-related shin pain, which tends to hurt on palpation of the tibia, in ECS there is generally no bone pain on palpation. ECS involves a tightening, restrictive pain that becomes worse with activity. This is believed caused by increased pressure within the compartment during activity.

We will consider both types of shin pain as we explore the differential diagnosis in the patient whose case has just been described—a differential that

The physical exam for shin splints

FIGURE 1

Pronation of feet



Assess foot mechanics to look for inward rolling arches, known as pronation. If the patient has MTSS, pronation can be controlled with the use of orthotic inserts, which minimize the load on the medial tibia.

FIGURE 2

Palpation of the posterior-medial tibia



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In cases of MTSS, there is a diffuse area of pain with palpation of the posterior-medial tibia, whereas with a tibial stress fracture, there is a focal area of pain. Pain along the posterior-medial tibia most often occurs as a result of mechanical loading from the excessively pronated foot.

FIGURE 3

Palpation of the anterior tibia



Pain along the anterior tibia, caused by distraction forces at this front part of the bone, tends to worsen with activity. Anterior tibial stress injuries are more serious than those of the posterior-medial tibia, and should be referred.

FIGURE 4

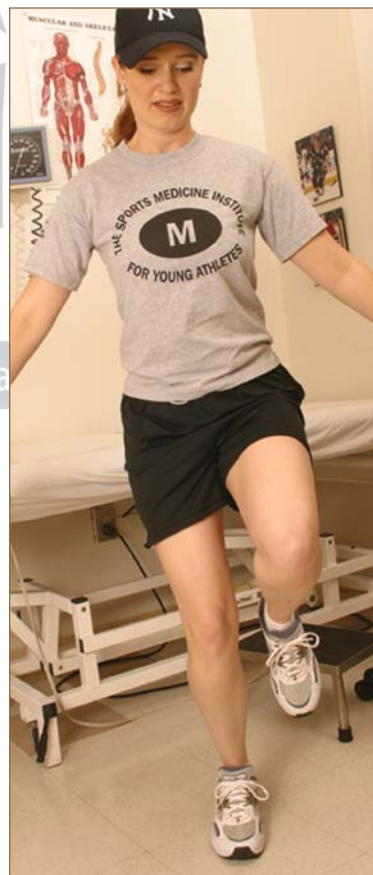
Palpation of the anterior compartment



In most cases of ECS, the affected compartment is the anterior. The tibialis anterior muscle will feel tight after running and can be painful on palpation for several days afterward. The pain is felt in muscle, not along the tibia.

FIGURE 5

The hop test



In a patient with a stress fracture, the compressive force between the ground and the skeleton will cause pain in the affected leg(s) when it is hopped on. Each leg should be tested.

includes MTSS, tibial stress fracture, peripheral neuropathy, lumbar radiculopathy, and ECS.

Medial tibial stress syndrome

MTSS is the most common cause of shin pain in athletes, especially those who participate in repetitive activities such as running and jumping; its exact incidence is unknown.⁶ Clinical diagnosis is made by history and physical examination. Diffuse pain and tenderness across the posterior-medial aspect of the tibia, normal radiographs, and the absence of neurologic findings are usually adequate to make the diagnosis.⁷ Michael and Holder,⁸ in their definition of MTSS, include clinical characteristics of dull aching to intense pain that is alleviated by rest; tenderness over the posterior-medial border of the tibia; and the absence of neurovascular abnormalities.

Early in the disorder, pain occurs at the beginning of a workout but resolves during activity, only to return upon completion of exercise. In later stages, pain is often sharper and occurs throughout the workout. In a severe case, the person may experience pain throughout the day and sometimes at rest.

Physical exam. Patients with MTSS usually complain of diffuse pain along the middle and distal thirds of the posterior-medial tibia. (This contrasts with tibial stress fracture, in which there is a single area of point tenderness at which a fracture has occurred.) Palpation of the tibia elicits pain; Figure 2 identifies the point at

Patients with MTSS usually complain of diffuse pain along the middle and distal thirds of the posterior-medial tibia.

which a patient would have pain if she has MTSS. The pain of MTSS can sometimes also be elicited by maneuvers that stretch or contract the soleus, such as plantar flexion against resistance, passive ankle dorsiflexion, standing on tiptoes, and hopping or jumping in place.

Diagnostic studies. Radiographs are usually normal in MTSS. Most cases are diagnosed based on history and clinical examination alone, and further studies are usually unnecessary. If the diagnosis is unclear, however, magnetic resonance imaging may be warranted to rule out tibial stress fracture. MRI can show medullary edema in some cases of advanced MTSS, but is usually not needed in treating MTSS.

Treatment includes a period of relative rest, the length of which varies depending on the patient and the severity of bone pain; three to four weeks is a general estimate. Because MTSS can develop into a stress fracture if the athlete is allowed to “run through the pain,”

we generally don't recommend nonsteroidal anti-inflammatory drugs in patients with bone injuries, as they diminish the symptoms. Ice is helpful both as an analgesic and anti-inflammatory agent with each of the conditions discussed in this article, and should be used for 15 minutes an hour as initial therapy.

Variables that led to the bone overload injury need to be assessed, including foot biomechanics (pronation), training level, running surface, and shoes. Many of these variables can be changed to prevent repeat injury; measures include corrective orthotics and exercise shoes designed to limit motion in the foot when it makes contact with the ground.

Tibial stress fracture

Along the continuum of bone overuse injury, tibial stress fracture represents a more serious injury than MTSS, although the presentation of the two conditions is very similar. Tibial stress fracture often occurs in running and jumping sports. The pain usually begins as a dull ache during training, progressing to severe pain throughout the day and night. As in MTSS, a patient may have pain at the posterior-medial margin of the tibia.

But there are differences, both clinical and radiographic, between MTSS and stress fracture (see the table on page 41). In MTSS, there is generalized tenderness along the posterior-medial tibia, the athlete can usually continue running, and radiographs are normal. In athletes with a stress fracture of the tibia,

Distinguishing the cause of shin splint pain

	Medial tibial stress syndrome (MTSS)	Tibial stress fracture	Lumbar radiculopathy	Exertional compartment syndrome (ECS)
Pain during activity	Yes	Yes	Occasionally	Yes, sensation of tightness
Pain after activity	Yes; increases as severity of MTSS increases	Yes; can be difficult to walk	Usually	Rarely; pain abates after exercise
Bone tenderness	Yes; generalized	Yes; point tenderness	No	No
Radiographic findings	No	Can manifest as fracture line in advanced stage	Sometimes, as in spondylolisthesis	No
MRI findings	Can manifest as general medullary edema	Can manifest as medullary edema with fracture line	Yes; lumbar disk herniation often present	No
Activity modification	Limit running sports Find reason for stress injury	No running Consider crutches, depending on site of injury Consider sports medicine referral	No running Consider referral to sports medicine specialist or neurologist with sports medicine interest	Running as tolerated Strongly consider referral to sports medicine for ECS testing
Pearls	Consider the contribution of running mechanics, foot mechanics (pronation), and amount of running	In addition to considerations in MTSS, investigate and consider bone density and the presence of anterior or posterior tibial injury	Keep in mind anatomic conditions that cause radicular pain (lumbar disk herniation, spondylolisthesis)	Pain only upon activity is a hallmark Clinical suspicion alone is not an indication for surgery; diagnostic testing is also required Common cause of chronic shin splint pain

tibial pain is generally acute and localized, pain generally limits the ability to run, and radiographs may show evidence of stress fracture through the cortex of the tibia in the advanced stage.

The pain of tibial stress fracture can occur in the posterior-medial tibia (Figure 2) or in the anterior tibia (Figure 3). Of these two sites, the anterior tibial stress fracture is more clinically worrisome because of the distraction forces that are displaced on the tibia with running. Anterior tibial stress fractures occur on the convex side of the tibia and are known as tension-side in-

juries because they displace further with the force of walking and running. Anterior injuries generally require more aggressive management, including a period of non-weight bearing, and should be referred to a sports-oriented orthopedist or sports medicine specialist.

Physical exam. Extreme point tenderness on palpation is the most important physical finding of tibial stress fracture. Patients often exhibit tenderness at the posterior-medial margin of the tibia near the middle and distal thirds of the bone.⁹ The gait is often hesitant and the patient can be reluctant to bear full weight on the

injured extremity. The hop test is generally positive—the tibia is painful when the patient lands on the leg.

Diagnostic studies. Although plain radiographs are often normal, they are still the initial diagnostic imaging technique of choice. In the early phase, the fracture may appear as lucency in compact bone, in contrast to the more radiopaque appearance of cancellous bone. The gray cortex sign (a focal area of graying of the cortex) has been described as an early sign of stress injury.¹⁰

Bone scans have long been the standard for diagnosis of stress fracture. However, because of the time,

Understanding compartment syndrome

Each muscle or group of muscles is enclosed in a compartment that is bound by fascia and bone. A firm knowledge of the four major compartments of the lower extremity is crucial to understanding the pathophysiology and diagnosis of exertional compartment syndrome (ECS) (see figure below).

Anterior. The compartment most often affected in ECS, the anterior space consists of the tibialis anterior, extensor digitorum longus, extensor hallucis longus, and peroneus tertius. The borders of the anterior compartment are the tibia, fibula, interosseous membrane, and anterior intramuscular septum.

Lateral. Comprising the peroneus longus and peroneus brevis, the lateral compartment also contains the common peroneal nerve (superficial and deep branches). This compartment is bordered by the anterior intramuscular septum, fibula, posterior intramuscular septum, and deep fascia.

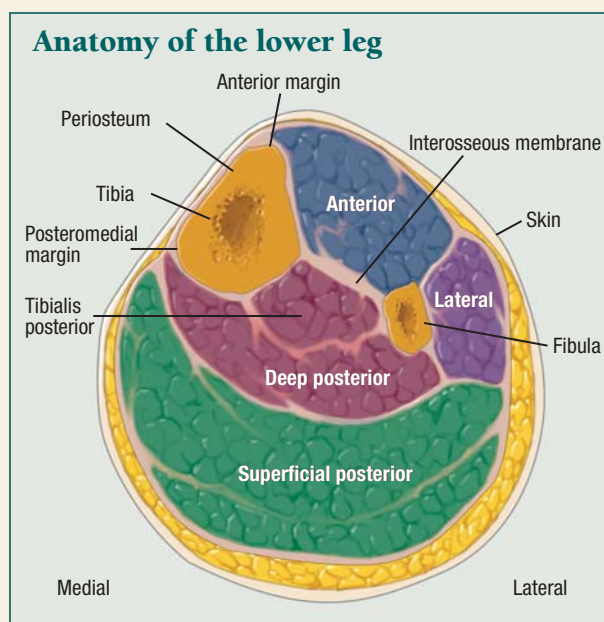
Superficial posterior. Surrounded by the deep fascia of the leg, the superficial posterior compartment contains the gastrocnemius, soleus, and plantar muscles.

Deep posterior. This compartment lies between the tibia, fibula, deep transverse fascia, and interosseous membrane.¹ Muscles in the

compartment include the flexor digitorum longus, flexor hallucis longus, popliteus, and tibialis posterior. Also included in this compartment are the posterior tibial artery and vein and the tibial nerve.

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cost, radiation exposure, and inability of bone scan to show medullary edema or a fracture line in bone (findings used to distinguish a stress injury from a stress fracture), MRI has replaced bone scan as the study of choice for the diagnosis of overuse injury to bone.⁹

Treatment. Stress fracture of the tibia can be viewed as a more

advanced stage of MTSS. Any stress fracture, particularly an anterior-tibial stress fracture, should be referred to a specialist. Depending on the site of injury, treatment varies from a period of limiting activity that stresses the bone and engaging in cross-training (swimming is a great way to maintain cardiovascular fitness while not loading the

bone), to a four- to six-week period of non-weight bearing on crutches. In general, if a bone injury is still painful, either to palpation or with bone loading during the hop test, then the injury has not been fully treated and requires more time to completely heal.

Bone density is an important contributing factor in stress fractures in

A hallmark feature of exertional compartment syndrome is that the physical exam, performed with the patient at rest, is completely normal.

adolescents and young adults and should be addressed in addition to biomechanical issues and pronation. Variables that can undermine adolescent bone density include inadequate calcium intake (less than 1,500 mg/day); amenorrhea for longer than five or six menstrual cycles; and a family history of osteoporosis. When amenorrhea, osteoporosis, and anorexia occur together, they are collectively known as the female athlete triad. Increasingly, dual energy X-ray absorptiometry (DEXA) is being used to obtain a baseline bone density value for the adolescent suspected of having osteoporosis, although this is not an official recommendation of the American Academy of Pediatrics. Supplements should be recommended if the patient is not getting the 1,500 mg/day of calcium, and 400 IU/day of vitamin D, recommended by the AAP for growing teenagers.

Peripheral neuropathy

Although very rare in children and adolescents, nerve compression or entrapment can cause lower extremity pain in active young children. The common peroneal nerve can be compressed where it passes around the fibular head. In such a case, the history and physical exam suggest pain in this area and electrodiagnostic studies can pinpoint the exact location of the lesion. The pain of peripheral neuropathy tends to be more like muscle-related pain than bone related (nonfocal pain and no pain on palpation of bone).

Leach and colleagues¹¹ reported on a group of seven runners and

one soccer player with peroneal nerve compression neuropathy secondary to exercise. Running incited pain, numbness, and tingling to varying degrees in all patients, and examination after running revealed muscle weakness and a positive percussion test where the nerve winds around the fibular neck. The diagnosis was confirmed by nerve conduction velocity studies in the five patients on whom the test was performed; other studies served primarily to exclude other causes of pain.

The superficial peroneal nerve may be affected by a muscle tear or by any recent trauma, particularly an ankle sprain.¹² The nerve is most commonly compressed as it exits the deep fascia to become subcutaneous. There may be focal tenderness in the area where the nerve exits (11 cm above the medial malleolus) while the patient dorsiflexes and averts. The patient will complain of activity-related pain. Weakness may be present.

Lumbar radiculopathy

The probability of spinal stenosis is extremely low in a young athlete; patients suffering from spinal

stenosis are almost always middle age or older. They often have a history of low back pain, with a newer onset of lower extremity pain. As with peripheral neuropathy, the pain of lumbar radiculopathy tends to be more like muscle-related pain than bone related. The history and physical are crucial to diagnosis.

Symptomatic disk herniation can be found in all age groups, with a peak incidence in patients between 35 and 45. Given that the patient whose case is described here is a young athlete with a complaint of lower leg pain, taking a short patient history aimed at uncovering a possible herniated disk is well worth the time. A physical exam can help rule in or rule out this diagnosis. Sciatica, characterized by pain radiating down the leg in a dermatomal pattern, is found in as many as 40% of patients with lumbar disk herniation.¹³ The patient with disk herniation will often complain of pain with bending forward and when straightening the leg, the action mimicking the straight leg test. Discogenic back pain is generally confirmed with an MRI scan.

Disk herniation is usually preceded by degenerative changes inside the disk. Tears in the annulus progress to radial tears that can ultimately lead to disk herniation or disruption. In a noncontained disk herniation, the annulus becomes completely disrupted. In a contained disk protrusion, the annulus fibers remain intact. The pain often associated with disk herniation can be caused by pressure on the nerve root or from breakdown products of a degenerated nucleolus pulposus.

Continued on page 47

The treatment of discogenic back pain in the adolescent begins with physical therapy to reduce the muscular forces around the lumbar spine. Surgery is rarely necessary in adolescents.

Exertional compartment syndrome

ECS represents a common and often undiagnosed muscular cause of shin splint pain. ECS is characterized by exercise-induced pain and swelling that are relieved by rest.

Each muscle or group of muscles is enclosed in a compartment bound by fascia and bone. The box on page 43 shows and describes the four major compartments of the lower extremity. In compartment syndrome, perfusion pressure falls below tissue pressure in a closed anatomic compartment, with subsequent compromise of vascular supply and tissue function. ECS results from the repetitive loading or exertional activity that an athlete experiences on a daily basis. The pathophysiology of ECS is incompletely understood, but it is generally accepted that elevated intracompartmental pressure causes ischemia of involved muscles.¹⁴ Elevated intracompartmental pressures have been found both during and after exercise in patients with ECS.¹⁵ Several studies have demonstrated a reduction in intracompartmental pressure after fasciotomy.^{16,17}

Case in point

The 14-year-old soccer player whose case is described at the beginning of this article displays a

FIGURE 6

Compartment pressure testing



Compartment pressure testing is performed under sterile conditions, using a large-bore needle and a pressure manometer to assess the intracompartmental pressure of specific compartments in the leg. Readings are taken at rest and then repeated after exertion. In our center, the test is performed with the aid of a treadmill to standardize the testing protocol.

MICHAEL ROGOL/PHOTOGRAPHY

typical presentation of ECS. She complains of “tightness” over her shins that becomes worse with exercise. Some patients may also describe the discomfort as a “cramping” sensation of the affected extremity with exercise. It is important to realize that the intense pain of ECS ceases when the patient stops activity. Pain is usually described as constant during exercise, and is unrelated to ground contact, as opposed to the discomfort of a tibial stress injury. Nonsteroidal anti-inflammatory medications are largely ineffective.

Physical exam. A hallmark feature of ECS is that the physical exam, performed with the patient at rest, is completely normal. Unlike cases of tibial overload, there is no bone tenderness to palpation. ECS can, however, occur

simultaneously with a tibial stress injury—in which case there will be tibial tenderness as well as firmness and pain over the affected compartment during running. The patient will often describe “tightness” over the front of the lower leg—more than 80% of ECS cases involve the anterior compartment.¹⁸

The neurosensory examination is usually not helpful in the patient with ECS, as it is usually normal.

Diagnosis. The history is the key component. It is essential for the clinician to listen for a description of leg tightness and pain that occur only with exertion and disappear afterward. Unlike bone-related pain, ECS does not produce symptoms without exertion. In addition, whereas radiographs, MRI, and bone scan help show bone injuries such as tumors and overuse injury

Do you have a question about shin splints or another sports medicine topic?

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Then come ask the expert!

Pediatric sports medicine authority (and author of this article on shin splints) Jordan D. Metzl, MD, will be appearing at the *Contemporary Pediatrics* booth at the AAP conference in San Francisco. Bring your questions—and run with them!

Date: Sunday, October 20

Time: 11:00 am to 12:00 noon

Place: Exhibit Hall booth #1311, Moscone Convention Center, San Francisco

SHIN SPLINTS

to bone, these tests are normal in cases of ECS.

The gold standard for confirming ECS is the compartment pressure study. A large-bore needle is inserted into the affected muscular compartment and then connected to a pressure monitor (Figure 6). Readings are taken before running and after five or more minutes of running on a treadmill or other pain-reproducing activity.

Pedowitz and colleagues defined criteria for diagnosis of anterior (the most common) chronic ECS in the leg.¹⁸ These include one or more of the following:

- pre-exercise pressure >15 mm Hg
- post-exercise pressure >30 mm Hg at one minute
- post-exercise pressure >20 mm Hg at five minutes

Treatment. The initial treatment for ECS, as diagnosed by compart-

ment pressure testing, is rest and physical therapy. In many cases, however, this approach fails. Any case of ECS that does not respond to rest and physical therapy should be referred.

The treatment of choice for ECS is elective fasciotomy of the affected compartment.^{17,19} Surgical therapy is based on the belief that intracompartmental pressure needs to be decreased. This is done by releasing the fascial barrier of the involved compartment through fasciotomy. Results from ECS surgery are generally good, with reports of symptomatic cure or improvement in most cases.¹⁶

Our 14-year-old soccer player was given a diagnosis of ECS in the anterior compartment of both legs. She underwent bilateral, anterior fasciotomy in April and by the middle of June was practicing with her summer soccer team—at full effort! □

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