



Musculoskeletal Case No. 12, August 2003

This is a PASSOR Recognized case

Presenting Symptom(s): Exercise induced foot pain in a runner

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Appropriate Audience: Residents and practicing physicians

Learning Objectives: After completing this educational activity, participant will be able to:
1) learn how to obtain an accurate history for patients presenting with exercise induced foot pain, 2) describe appropriate physical exam findings that help to distinguish the various entities that can cause exercise induced foot pain, and 3) describe appropriate diagnostic studies to use in patients with exercise induced foot pain.

This case is no longer available for CME credit.

History

An 18 year old male runner was referred to our sports medicine clinic with a 1 year history of left foot pain. He was a national high school cross country champion and was recruited as a scholarship athlete at a Division 1 collegiate running program. His symptoms developed insidiously when he increased his speed training about 1 year previous, with the development of diffuse left foot pain and tightness that would develop after about 20 minutes of exercise. The patient also noted occasional cramps in his calves after excessive exercise. He did not notice any swelling, numbness, tingling, or burning sensations in his lower extremities. In spite of this, the patient was able to achieve a high level of competitive long-distance running.

- Prior to continuing, please develop a differential diagnosis and list each possible diagnosis in order of likelihood.
- Is there any additional information regarding the history that might be helpful in clarifying your differential list or changing its order of priority?

Commentary I

Differential Diagnosis

- Exercise induced compartment syndrome
- Soft tissue injury
- Stress fracture
- Tarsal tunnel syndrome
- Neuroma
- Sciatic, tibial, or peroneal neuropathy
- Lumbar radiculopathy
- Tarsal coalitions



The diffuse nature of the patient's cramping foot pain elicited only with exercise is most suggestive of an exercise induced compartment syndrome. These typically involve one of the four compartments of the leg, and more rarely occur in the foot. Patients typically complain of aching or crampy leg or foot pain, tightness, or even weakness. The symptoms generally begin within 20 minutes of the onset of running, and usually resolve shortly after the termination of exercise. The symptoms are often located along the involved muscle and may be associated with numbness or tingling in the distribution of the nerve traversing the compartment.

Any time there is a history of foot pain evoked by exercise in a young distance runner, soft tissue injury or stress fractures should also be considered. Common soft tissue injuries in runners include plantar fasciitis, or tendinopathy of the posterior tibial, peroneal or extensor tendons. Common stress fractures of the foot can involve the calcaneus, navicular, or metatarsals, and less likely the cuboid or cuneiform bones. Local nerve involvement from tarsal tunnel syndrome or an interdigital neuroma should be considered along with more proximal nerve referral from a lumbosacral radiculopathy or sciatic neuropathy.

Most soft tissue injuries cause pain first thing in the morning and with day to day activities, but reduced pain during physical activity. Stress fractures of the foot often present with more localized pain that occurs earlier during the physical activity and lingers longer, and with continued training pain will be present throughout the run and persist into daily ambulation. Interdigital neuromas present with burning paresthesias and occasionally numbness in the affected interspace, most commonly the third, whereas patients with tarsal tunnel syndrome usually complain of pain, burning, or tingling on the plantar aspect of the foot. There is often a positive Tinel's sign with percussion of the nerve along the tarsal tunnel or medial or lateral plantar branches that reproduces the patient's symptoms. Lumbosacral radiculopathies typically present with pain or sensory symptoms corresponding to a specific dermatome and nerve root. Sciatic, tibial, or peroneal neuropathies may present with similar distal symptoms as a radiculopathy, but without low back pain.

Tarsal coalitions (congenital fusions of the foot) can also present with ankle or foot pain. Examination often reveals reduced range of subtalar and midtarsal joint movement that may be painful at the end range.

- Is there any additional information regarding the clinical history that might be helpful in clarifying your differential list or changing its order of priority?

History, continued

He saw numerous physicians and tried physical therapy for a diagnosis of tendinitis, interdigital nerve block for suspected neuroma, and was even immobilized in a walking cast for more than 1 month for a presumed stress fracture, all without effect. He was then reportedly diagnosed with a compartment syndrome of the foot by compartment pressure measurements and surgical repair was recommended. Results of 2 magnetic resonance imaging scans on 2 separate occasions showed no abnormalities in the foot or ankle. Results of blood studies, including cell count, electrolyte, and chemistry panel, were normal.



- If necessary, revise your differential diagnosis based on the additional clinical history.
- On which details of the physical examination should you focus at this point?

Physical Examination

He had no pain with deep palpation of the bones or muscles of the foot. Manual muscle testing of all foot and leg muscles was 5/5 bilaterally and there was no pain provocation. Motor, sensory, and reflex examinations were intact in both lower extremities. He had full range of motion in the cervical and thoracolumbar spine. There no evidence of adverse neural tension with straight leg raise or slump tests. Tinel's test was negative at the fibular head and tarsal tunnel. Metatarsal compression test was negative. He had full, pain free range of motion in the ankle, subtalar, and midtarsal joints.

History, continued

The patient's past medical history was unremarkable and he was not taking any medications. A more detailed review of symptoms, however, revealed that cold weather or immersing himself in cold water, such as in a pool, could produce cramping of his hands, feet, or jaw. A family history revealed similar symptoms in his sister and uncle (his mother's brother). His mother also had very mild symptoms of hand cramping with exposure to cold weather (less than 25°).

- At this point, review your differential diagnosis and revise as appropriate.
- Are there additional observations on physical examination that might be helpful in narrowing your differential list?

Commentary II

Differential Diagnosis

- Exercise induced compartment syndrome
- Hereditary motor or sensory neuropathy
- Neuromuscular disease
- Myotonic syndrome

The positive family history suggests a hereditary component to the patient's condition. The most common hereditary disease evolving in adolescent or young adult age is a hereditary motor and sensory neuropathy or hereditary muscular disease including muscular dystrophy or myotonic syndrome. For differentiation, more detailed neurological examination and skeletal inspection are needed. Common athletic problems like stress fracture or soft tissue injury, and peripheral neuropathy, radiculopathy, and tarsal coalition are unlikely at this point, given the lack of specific abnormal findings on physical examination.



Physical Examination, continued

On physical examination, the patient had no atrophy or fasciculations of his extremities or tongue. No percussion myotonia was noted. There was no evidence of frontal balding or temporalis muscle wasting. Further neurologic testing including full motor and sensory testing of the upper extremities, mental status screen, cranial nerves, coordination, and gait, were within normal limits, except for mild proximal muscle weakness noted at the deltoids and triceps rated at 4/5 bilaterally.

Commentary III

Unfortunately, no specific findings are revealed from physical examination. Normal stretch reflexes and normal sensory exam decrease the possibility of a peripheral neuropathy or radiculopathy. The mild proximal upper extremity weakness with normal sensory exam is suspicious for a myopathy or myotonic syndrome.

Physical Examination, continued

Immersion of the patient's right hand in ice water for a period of approximately 45 seconds revealed no myotonia or cramping. To demonstrate his symptoms, he was asked to run. After 20 minutes, he began to experience cramping, which started with a feeling of tightness on the plantar surface of the left foot. The more he continued to run, the more the symptoms were aggravated and evolved to the toes curling with intrinsic muscle spasm. Ten minutes after stopping the run, the patient's symptoms resolved.

- What condition is now at the top of your differential?
- What diagnostic tests would you order at this time?

Commentary IV

Differential Diagnosis

- Myotonic syndrome
- Myopathy
- Peripheral neuropathy
- Exercise induced compartment syndrome

The first condition that a physician has to consider when encountering familial cold sensitive muscle spasm is a myotonia. Myotonia is aggravated by cold or resting for a while before movement and improved by repeated exercise. This case only has evidence of cold sensitivity.

With the history and the physical examination of exercise induced cold sensitive muscle cramping, family history, and nonspecific physical examination except equivocal shoulder weakness, electrodiagnostic evaluation is a reasonable choice to help narrow down the differential diagnosis



Test Results

Nerve Conduction Studies			
Nerve	Distal Latency(msec)	Amplitude (uV/mV)	Conduction velocity(m/sec)
Peroneal motor Left	4.2	8	57
Superficial peroneal sensory Left	3.6	14	39
Post. tibial motor Left	3.9	22	53
Sural sensory Left	3.2	20	44
Medial plantar sensory Left	3.2	19	44
Lateral plantar sensory Left	3.2	11	44
H-Reflex Left	28.4		
H-Reflex Right	28.4		

Needle EMG Studies				
Muscle	Insertional activity	Spontaneous Wave		MUP
		Fibrillation/PSW	Other	
Vastus medialis Left	Increased	None	3+ Myotonicdischarges	Normal
Tibialis anterior Left	Increased	None	3+ Myotonicdischarges	Normal
Gluteus medius Left	Increased	None	3+ Myotonicdischarges	Normal
Extensor hallucis longus Left	Increased	None	3+ Myotonicdischarges	Normal
Gastrocnemius medial head Left	Increased	None	3+ Myotonicdischarges	Normal
First dorsal interosseous Left	Increased	None	3+ Myotonicdischarges	Normal
Biceps brachi Left	Increased	None	3+ Myotonicdischarges	Normal
Paravertebral L4-5 Left	Increased			
Paravertebral L5-S1 Left	Increased			

PSW: positive sharp wave; MUP: motor unit potential

Results of motor and sensory nerve conduction studies were normal. A needle electromyography(EMG) study at rest demonstrated abnormal sustained runs of positive sharp waves at virtually every needle site in all limbs studied. Motor unit potentials and recruitment were normal in all muscles. Following immersion of his hands in cold water for



approximately 4-5 minutes, a repeat needle examination of his first dorsal interosseous in the hand showed a large amount of myotonic discharges

- If necessary, augment or change the clinical impression based on the test results.

Commentary V

Myotonic discharges can occur in various diseases with or without clinical myotonia. Clinical myotonia is the phenomenon of delayed muscle relaxation following muscle contraction and usually accentuated by muscle activity following a period of rest. "Warm up", continued muscle contraction, lessens the myotonia. Generally, cooling worsens the myotonia, but the most dramatic worsening is observed in paramyotonia congenita. In addition, myotonic dystrophy, congenital myotonia, hyperkalemic periodic paralysis, polymyositis, and acid maltase deficiency can reveal myotonia. Infrequent myotonic discharges may be seen with some drugs, like diazacholesterol, triparanol, clofibrate, and propranolol. With normal nerve conduction studies and needle electromyogram studies, myopathy, peripheral neuropathy, and radiculopathy are excluded. Cramping/fasciculation syndrome is also excluded because of the absence of fasciculations on clinical and electrodiagnostic testing.

In addition to a distal myopathy or myotonic syndrome, other causes of muscle cramping or stiffness include continuous muscle fiber activity or neuromyotonia, myokymia, stiffman syndrome, tetany, and tetanus.¹ These diseases can be easily excluded with history and electrophysiologic studies.

- What additional diagnostic testing would you order?

Commentary VI

The patient had a reported history of high compartment pressures in the foot from an outside physician and thus, to rule out a superimposed compartment syndrome of the foot, repeat compartment pressures, pre- and postexercise, were ordered.

Test Results, continued

A Stryker examination of the medial, central, and deep posterior compartments of the left and the central compartment on the right leg performed pre- and postexercise were within normal limits. Further tests were also ordered to evaluate for signs of myotonic dystrophy or other myopathy or inflammatory disorder including ophthalmologic examination to evaluate for cataracts, thyroid function tests, and fasting serum glucose tests, all which were within normal limits. Serum creatinine phosphokinase (CPK) was 687 IU/L (normal range for men, 35 -32 IU/L). Repeated CPK study and aldolase after 2 weeks rest from running was 669 IU/L and 9 (normal range, 1-8). He also underwent a muscle biopsy from the quadriceps with normal findings.

- What is the impact of the additional test results on the final diagnosis?
- Considering all the data from the history, physical examination and laboratory studies, what is/are your final diagnostic impression(s)?

Final Diagnostic Impression

Paramyotonia Congenita



Commentary VII

Our patient had a relatively benign disorder that was longstanding and was clinically characterized by foot myotonia that worsened with repetitive muscle contraction, but not induced by abrupt movement following a period of rest, and hand stiffness that worsened with exposure to cold. For additional examination of myotonia, repetitive nerve stimulation test after exercise can be helpful, because post exercise decrement phenomenon is observed in patients with clinical myotonia, but this was not done in this case because the standard EMG findings were so dramatic. The patient's family history indicated an autosomal dominant inherited disorder. These features are characteristic of paramyotonia congenita. Although the typical paralysis after myotonia was absent in our patient, his myotonic symptom that was significantly prolonged after exercise and his cold sensitive myotonia are more compatible with paramyotonia congenita than with other myotonic syndromes.

- What treatment would you now initiate for this patient?

Commentary VIII

He was initially treated with a trial of carbamazepine and then mexiletine; however, these were both discontinued secondary to reported adverse effects of subtle cognitive slowing. He was given a low dose of phenytoin (400 mg q hs), which lessened his myotonia and allowed him to continue running with minimal symptoms, provided he maintain his running mileage at less than 50 miles per week and that he run on softer surfaces and modify his workouts during colder weather. Eventually, he decided to give up running, as he was not able to maintain mileage high enough to compete successfully at an elite college level and he did not want to continue on medication.

Final Discussion

Paramyotonia congenita is a rare autosomal dominant disease, characterized by cold-induced myotonic stiffness, which is increased by sustained muscular activity (paradoxical myotonia) and may be followed by a variable degree of weakness.² Paramyotonia congenita is now classified together with hyperkalemic periodic paralysis, some forms of hypokalemic periodic paralysis, and potassium-aggravated myotonias in the group of hereditary sodium channelopathies.³⁻⁵

The differential diagnosis for paramyotonia congenita includes myotonia congenita and myotonia dystrophy. Myotonia congenita is distinguished by stiffness that decreases with warming-up exercises and does not show typical cold temperature provocation. Myotonic dystrophy, the most common myotonic syndrome, is a progressive, multisystem disease associated with muscle atrophy, cataracts, cardiac arrhythmias, testicular atrophy, and other endocrine abnormalities.¹ These features were absent in our patient. The other specific myotonic disorder for differential diagnosis is a proximal myotonic myopathy (PROMM). This disease is predominantly characterized by proximal weakness without atrophy, muscle pain, cataracts, myotonia, cardiac disturbances, and gonadal dysfunction.⁶ Even though our patient had subtle weakness in bilateral proximal upper extremities, other features did not bear out a diagnosis of PROMM.⁷



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