The Athlete With Muscular Cramps: Clinical Approach

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Abstract
Muscle cramps are involuntary, painful, spasmodic contractions of the skeletal muscle. Although cramps are a common clinical complaint, their etiology and management have not been well established. Exercise-associated muscle cramps occur during or immediately following exercise, and they are associated with muscular fatigue and shortened muscle contraction. The main challenges for treating physicians are to identify whether the complaint represents a true muscle cramp as well as to rule out the presence of an underlying serious clinical condition. Muscle cramps may be a symptom of any of several conditions, including radiculopathies, Parkinson’s disease, hypothyroidism, diabetes mellitus, vascular problems, electrolyte disorders, and metabolic myopathies. Cramps also may occur as a side effect of certain drugs (eg, lipid-lowering agents, antihypertensives, β-agonists, insulin, oral contraceptives, alcohol). Most athletes who experience exercise-associated muscle cramps are healthy individuals without systemic illness. Therapy should focus on preventing premature fatigue by means of appropriate nutrition and adequate training.

Muscle cramps are a frequent complaint in the general population and represent one of the most common clinical problems among athletes. Cramps—sudden, painful, and involuntary contractions of the skeletal muscle—are clinically characterized by acute pain, persistent soreness lasting 2 to 3 days, swelling, and elevated serum creatine kinase levels. Explosive onset and visible, palpable contractions are usually present in one muscle group or segment, associated with both trivial movement and forceful contraction; stretching or agonist countercontraction usually brings prompt cramp relief. Electromyogram [EMG] recordings of the affected area show rapid repetitive muscle firing.

Most people have experienced at least one episode of muscle cramping, but the incidence of cramping in athletes is not known. Lifetime incidence in marathon runners and triathletes has been reported to be as high as 30% to 67%, and muscular cramps are considered very common among tennis and football players. Difference in prevalence between elite and recreational players has not been studied.

Muscle cramps may occur in association with diseases of the lower motoneuron, with metabolic disorders, following acute extracellular volume depletion, with inherited syndromes, and as a side effect of medication. However, in some patients (and commonly in the elderly), cramps occur for no detectable reason. Furthermore, athletes pre-
Exercise-Associated Muscle Cramping

EAMC is defined as painful, involuntary contractions of skeletal muscle that occur during or after physical activity, typically involving the lower leg muscles. EAMC is a common problem among athletes, particularly in those who participate in endurance sports such as running, cycling, and swimming. The condition is typically brief and resolves within minutes, but it can be painful and disruptive to athletic performance.

Etiology and Classification

Controversy persists regarding the classification of muscular cramps. Parisi et al. described a pathogenesis-based classification for this muscular condition, establishing three different types of cramps: paraphysiologic, idiopathic, and symptomatic (Table 1). Paraphysiologic cramps develop in healthy people and are linked to certain circumstances and conditions, such as exercise and pregnancy. In idiopathic cramps, the muscular problem is the main symptom of a general disease; these can be sporadic, are sometimes inherited, and usually are not associated with cognitive, pyramidal, cerebellar, or sensory abnormalities. A central, neuronal origin at the motoneuron level has generally been hypothesized for these cases. Symptomatic cramps are manifestations of an underlying disease.

Exercise-associated Muscle Cramping

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muscle that occur during or immediately after exercise.3 Delayed or nocturnal cramps experienced by fatigued athletes also can be attributed to exercise. Proposed causes for EAMC included hereditary metabolic disorders, systemic fluid disturbances (eg, electrolyte concentration), and extreme environmental conditions. Serum electrolyte and fluid disturbances have been associated with the development of muscle cramps in athletes, but scientific evidence documenting this relationship is lacking. In a cohort study conducted in distance runners, Schwellnus et al6 found no clinically significant alterations in either serum electrolyte concentrations or in hydration status.6,7

A new etiology of EAMC has been proposed, supported by epidemiologic data and experimental animal studies on reflex spinal activity at rest and under fatigue conditions.6-11 These researchers postulate that EAMC occurs because of abnormal α motor neuron activity caused by aberrant control at the spinal level. This central factor in muscle fatigue generates loss of control through an excitatory effect on muscle spindle afferent activity (type Ia, type II) and an inhibitory effect on type Ib Golgi tendon organ afferent activity. An additional contributing factor that may trigger a cramp is muscle contraction within the shorter or inner range, which also inhibits Ib Golgi tendon afferent activity. Other studies support this theory.3,12

Among the muscles more commonly affected by EAMC are force-generating biarticular muscles, such as the triceps surae, hamstrings, and quadriceps. These muscles often are already contracted and in a shortened position during sports activities. Passive stretching results in almost immediate relief of cramping, reduction in EMG activity, and increased Golgi activity.2,3,12 This phenomenon is compatible with the hypothesis that abnormal spinal reflex activity is an important etiologic factor in EAMC. Some risk factors for EAMC have been identified in marathon runners, including older age, high body mass index, irregular stretching habits, and a family history of cramps.13 Inadequate stretching before exercise could increase myotonic reflex activity, thereby increasing spindle activity.

Although not yet fully explained, psychological factors may exert considerable influence on the pathophysiology of EAMC. Sachdev14 was unable to establish a significant relationship between golfers’ cramps and anxiety disorders. The hyperventilation and magnesium deficit associated with panic disorders may contribute to cramping experienced as a result of functional stress disorder.1 Muscle cramps are more frequently observed during competition rather than during training; however, no studies have been conducted on this empirical observation. Cramping also may be associated with extreme weather conditions; several football team physicians have reported muscle cramping episodes in hot weather conditions during hard preseason training.5

Symptomatic Cramps and Exercise

A variety of systemic diseases may have associated symptomatic muscular cramps. Although the athlete who experiences cramping usually does not suffer from an underlying disease, the attending physician should not exclude this possibility. Both central (eg, Parkinson’s disease) and peripheral (eg, amyotrophic lateral sclerosis) nervous system pathologies may be associated with muscle cramps. Muscle cramps are commonly found in patients with peripheral neuropathy; often preceded and accompanied by fasciculation in the same muscle group, the cramps are triggered after brief contraction of the susceptible muscle. Radiculopathy is likely one of the most common causes of nocturnal leg cramps and may be caused by radicular compression secondary to segmental vertebral instability at the L5-S1 level.1,2 Metabolic myopathies are disorders of substrate energy provision in skeletal muscles.15 The presence of muscular cramps during intense exercise is the hallmark of metabolic myopathies caused by glucose metabolism defects.1,15 Symptoms linked to disorders of fatty acid transport or oxidation and mitochondrial disorders may occur after endurance exercise. The presence of urinary pigments may indicate one of these uncommon muscle diseases. Other useful evaluations include ischemic forearm testing, electromyographic and nerve conduction velocity studies, muscle biopsy (for histology, enzyme, and DNA testing), and exercise testing. Most patients with metabolic myopathies can participate in athletic activities after appropriate exercise adaptation and dietary manipulation.15

Muscle cramps are common in patients with venous insufficiency or chronic obstructive arterial disease of the lower limb, which causes intermittent claudication. Vascular Doppler ultrasound studies should be included during the workup of the athlete with such a disorder who presents with recurrent cramps (Figure 1). Low serum magnesium levels may contribute to cramp physiopathology associated with vascular insufficiency.1

The patient with hypothyroidism, with or without myopathy, often reports exercise intolerance and cramps, possibly linked to inhibition of the respiratory chain.1 The patient with diabetes mellitus may also present with exercise intolerance and nocturnal cramps that are unrelated to the presence or absence of peripheral neuropathy.

Electrolyte imbalance has historically been associated with muscular cramps. Low ionizable serum magnesium and calcium levels produce severe muscular cramps (ie, tetany). In mild forms, the distal muscles are
affected, although any muscle may be involved; tetany cramps have been attributed to unstable axonal depolarization. The patient with hemodialysis often presents with cramping episodes caused by serum hypo-osmolarity or extracellular volume contraction. These cramps may be successfully managed using intravenous bolus injection of hypertonic saline or dextrose. Although a low serum potassium level may result in muscle cramps, true potassium deficiency is relatively rare; the use of a diuretic may also produce hypokalemia. Low sodium levels produce several neurologic alterations, including muscular cramps. Rapid dehydration caused by diuretic therapy, profuse perspiration, and diarrhea or vomiting frequently leads to cramps. So-called heat cramps occur after prolonged exertion under excessively hot and humid conditions; in these cases, etiology is likely sweat-induced hyponatremia or fluid replacement-induced osmotic shift. A wide spectrum of drugs can induce cramping syndromes through muscular or neuronal mechanisms. The physician should inquire regarding the use of lipid-lowering agents (clofibrate, fenofibrate, bezafibrate); antihypertensives (diuretics, β-blockers, calcium channel blockers, angiotensin-converting enzyme inhibitors); β-agonists (terbutaline, salbutamol); insulin, oral contraceptives, and alcohol. Creatine is an amino acid extensively used among athletes as a nutritional supplement. Anecdotal reports have suggested that creatine supplementation may promote dehydration, cramping, and musculoskeletal injury. However, a long-term safety study by Greenwood et al indicated that creatine supplementation did not increase dehydration, cramping, or muscle injury incidence among football players during intense training in hot, humid environments. At present, a consensus exists on reviewing the use of creatine supplementation in athletes who experience recurrent muscle cramps.

Most episodes of cramping in athletes occur in healthy individuals who have undergone strenuous physical activity and have reached fatigue. Athletes usually experience cramps at the end of prolonged, intense competition. Typically, fatigue is followed by muscle pain located on biarticular lower limb muscles (eg, triceps surae, quadriceps). This “cramp-prone state” is usually relieved once activity stops and passive stretching commences. This prodromal sign is followed by spontaneous spasmodic contractions and frank cramping when activity is resumed. Once the athlete ceases activity, cramping episodes are usually followed by cramp-free periods.

On physical examination, an athlete with acute localized cramps (one or two muscle groups) demonstrates muscle contracture and visible fasciculation. The athlete is conscious and responds normally to stimuli. Vital signs are normal, most patients are not dehydrated or febrile, and, in general, no additional studies are required.

Several diseases can produce cramping symptoms during exercise (Table 2). Metabolic disorders are rare genetic conditions; the patient with such a disorder may experience severe muscular cramps during exercise.
Myalgia, myoglobinuria, and rhabdomyolysis are common findings, and the EMG frequently is electrically silent. Metabolic myopathies are disorders of substrate energy provision in skeletal muscle. Clinical investigation of the type of exercise producing fatigue and cramps (endurance versus high-intensity) may guide the physician to the specific genetic diagnosis.

**Treatment of the Cramping Athlete**

**The Athlete With Acute EAMC**

Immediate treatment of the acutely cramping athlete requires passive stretching of the affected muscle groups and maintaining the stretched position until fasciculation ceases. Other measures include cooling the skin temperature, when excess heat is an issue, as well as oral hydration. Drug therapy (eg, diazepam, magnesium, quinine, calcium) is not recommended. When the urine is dark or scarce during the first hours, fluid replacement along with further clinical and laboratory study is recommended. Although no effect on cramps was noted by stimulating the skin at metameric level, frictional icing massage of the affected muscle groups may help to relieve painful muscle spasm in acute cases. The athlete presenting with severe or generalized cramps in muscles not subjected to exercise, or with localized cramping together with confusion, altered state of consciousness, or other signs of central nervous system involvement, should receive emergency medical attention. These patients likely suffer from a systemic disease, such as a metabolic disorder. Such patients require immediate hospitalization to rule out volume depletion, electrolyte imbalance, acute renal failure, intracranial disorders, or other systemic conditions. An algorithm for clinical treatment of the cramping athlete is summarized in Figure 2.

**The Athlete With Recurrent Cramps**

The presence of recurrent cramps is a common complaint among ath-

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**Figure 2**

Algorithm for clinical approach to the cramping athlete. $T^o =$ temperature

<table>
<thead>
<tr>
<th>Acute cases</th>
<th>Recurrent cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>True exercise cramps</strong></td>
<td><strong>Consider and rule out</strong></td>
</tr>
<tr>
<td>Normal consciousness</td>
<td>Diabetes</td>
</tr>
<tr>
<td>Fatigue</td>
<td>Hypothyroidism</td>
</tr>
<tr>
<td>In-competition</td>
<td>Vascular disease</td>
</tr>
<tr>
<td>Pre-cramp state</td>
<td>Metabolic myopathies</td>
</tr>
<tr>
<td>Normal diuresis</td>
<td>Radiculopathy</td>
</tr>
<tr>
<td>(consider physiologic exercise oliguria)</td>
<td>Drug use (diuretics, β-blockers, β-agonists, insulin, creatine, oral anticonceptives, contraceptives)</td>
</tr>
<tr>
<td>Normal body $T^o$</td>
<td>Others</td>
</tr>
</tbody>
</table>

**On-site Assistance**
- Rest
- Oral rehydration
- Comfortable environment ($T^o$, ventilation)
- Passive stretching
- $T^o$ and diuresis control
- Hold medications

**Clinical assistance emergency**

**Resolution of symptoms**
- Hydration
- Stretching
- Training-plyometrics
- Psychological

**Prevention strategies**
- Electromyogram
- Muscular biopsy
- Reconsider diagnosis

**Recurrence**
- Complete medical history and physical examination
- Laboratory analysis
- Emphasis on nutritional, orthopaedic, and neurologic assessment

**Algorithm for clinical approach to the cramping athlete. $T^o =$ temperature**

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![Algorithm for clinical approach to the cramping athlete.](image-url)
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The athlete who does not respond to initial treatment of recurrent EAMC requires further evaluation. Special investigations (eg, muscle biopsy) may be necessary to discover the cause of cramping and to rule out metabolic myopathy. Metabolic disorders of the muscle, such as McArdle disease, usually present contracture without EMG activity, suggesting a muscular origin. EMG activity recorded during cramping shows brief periodic bursts of high-frequency, high-voltage action potentials, suggesting neural origin. It does not differ fundamentally from muscle response registered during maximal voluntary contraction. Baseline EMG activity is greater and more variable in cramping athletes than in control subjects. Once the etiologic diagnosis of the underlying condition is confirmed, specific treatment is instituted and exercise adjustment is made.

Several drugs have been used to treat cramps, with variable clinical effectiveness. These include quinine sulfate, verapamil, carbamazepine, baclofen, gabapentin, phenytoin, vitamin E, creatine monohydrate, and L-carnitine. However, most studies have not included athletes. Quinine is commonly used to treat night cramps, but there are doubts about its effectiveness, and it has potential side effects (eg, tinnitus, thrombocytopepia, cinchonism-quinism). Very little evidence exists regarding the use of quinine for cramps in athletes, but safety and efficacy issues make it an unappealing option and, consequently, it is not recommended for use in athletes. Magnesium has been shown to play an important role in muscle and nerve function, but its role in muscle cramp pathogenesis remains unclear. Further investigation is needed to determine the effectiveness of magnesium supplementation on nocturnal leg cramps. One impressive finding in cramp drug trials, however, is a powerful placebo effect, reaching figures as high as 40% to 50%.

Prevention of EAMC

The key to preventing EAMC lies in preventing premature muscular fatigue during exercise. Athletes should be encouraged to be well conditioned for the activity; to routine-ly conduct periodic stretching, particularly of affected muscle groups; to maintain a well-balanced diet, including electrolytes and carbohydrates; to avoid fatigue during exercise; and to reduce the intensity and the duration of exercise, if necessary.

Summary

EAMC occurs during or immediately after exercise in force-generating muscles; this cramping is usually associated with fatigue. EMG studies of cramping muscles show increased muscle activity, supporting the hypothesis of a regional, rather than systemic, cause of EAMC. Current recommendations for prevention and treatment in the athlete with uncomplicated muscle cramps include rest, stretching, proper nutrition and hydration, and psychological intervention. Although not common, physicians should rule out other causes of cramps, such as Parkinson’s disease, hypothyroidism, metabolic myopathies, or drug effects (eg, lipid-lowering agents, antihypertensives, β-agonists).

References

Evidence-based Medicine: There is one level I/II prospective study (reference 19). The remaining references are mainly case-control reports or cohort studies (level III/IV) or expert opinion (level V) (references 12, 13, 15, and 18).

Citation numbers printed in bold type indicate references published within the past 5 years.

6. Schwellnus MP, Nicol J, Laubscher R,


