Chronic Exertional Compartment Syndrome and Forefoot Striking: A Case Study

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Chronic exertional compartment syndrome (CECS) of the lower leg is a common and debilitating condition that is characterized by recurrent pain and discomfort over the anterior compartment during running. Intracompartmental pressure testing can be an unreliable diagnostic procedure; current conservative management rarely provides satisfactory long-term outcomes; and surgical management can present complications. This case study describes the resolution of CECS symptoms after the self-adoption of a forefoot running gait.

Case Report

A 21-year-old male, with no significant past medical history, presented to his primary care physician with a 6-month history of bilateral lower limb pain experienced during running. The patient typically ran 21 miles a week, in addition to circuit training 2–3 times per week and playing in social football and rugby games. The pain typically progressed after 10–15 minutes of exertion and was focused on the anterolateral aspect of the lower leg. The pain was described as dull and achy, and was associated with a sensation of tightness across the affected area. There was no history of injury to either leg. The pain frequently caused cessation of exercise or slowing of running pace. Discomfort would ease after 5–10 minutes of rest, but would return almost immediately upon return to activity. On examination, there was no evidence of anatomical abnormality or overt pathology affecting the lower limbs. Full range of movement in both knees and ankles was demonstrated, along with normal muscle strength for movements at each of these joints. No pain was elicited by palpation over the posteromedial aspect of the tibia, the anterior compartment, or the fibula.

Differential Diagnoses

Differential diagnoses for lower leg pain include medial tibial stress syndrome (shin splints), stress fracture, and superficial peroneal (fibular) nerve entrapment syndrome. A history of pain precipitated by 10–15 minutes of exertion, relief of pain by rest, and lack of tenderness over the tibia excluded tibial pathology. The history of bilateral exertional pain, with no history of trauma and no anatomical abnormality of the lower limb, along with normal strength of the dorsiflexors, excluded superficial peroneal nerve entrapment.

Key Points

Chronic exertional compartment syndrome (CECS) is a common and debilitating syndrome.
Forefoot striking is associated with reduced anterior compartment pressure.
Adoption of a forefoot striking gait may address the underlying etiology of this condition.
Treatment

The patient was referred to a podiatrist for further evaluation, who identified pes planus. Custom orthotics were fabricated to support the arches and limit excessive pronation of the feet. Without much improvement from use of the orthotics, the patient sought assistance from a physiotherapist, who diagnosed chronic exertional compartment syndrome (CECS). The physiotherapist recommended regular massage of the affected area, the application of ice after exercise, and daily stretching of the muscles of the anterior compartment. On a final consultation, after little improvement with conservative management, the physiotherapist recommended orthopedic referral for consideration of compartment pressure measurement and possible fasciotomy. Shortly after this recommendation, the runner was introduced to the concept of forefoot running by another athlete. Subsequently, he slowly adopted a forefoot strike, increased running cadence, and shortened his stride length. He did this by adding 5 minutes of forefoot running to the end of his usual shod/heel-striking runs, aiming to land on the forefoot or mid-foot without excessive plantar flexion. He consciously shortened his stride length and increased his running cadence to roughly 180 steps per minute. Each week, he reduced shod running time by 5 minutes, and added a further 5 minutes to the amount of forefoot running time. After 8 weeks, he was forefoot running for 40 minutes. He trained on both hard surfaces (e.g., asphalt and concrete) and soft surfaces (e.g., grass). He wore Vibram FiveFingers footwear (Vibram S.p.A., Albizzate, Italy) for the transition to the new running technique. The patient experienced a dramatic resolution of his symptoms and remained pain-free one year later. He returned to running the distances completed prior to onset of symptoms and also returned to rugby competition. He reported delayed onset muscle soreness (DOMS) of the calf muscles during the early transition period, but described how this gradually resolved with training.

Discussion

The anterior compartment of the lower leg contains four muscles. Collectively, they are responsible for the control of dorsiflexion of the foot. Of these muscles, the tibialis anterior is considered the largest contributor to dorsiflexion. During rearfoot running, these muscles contract eccentrically at heel-strike to control plantar flexion (foot slap). The tibialis anterior muscle demonstrates a particularly high level of activity during this action, which may make it susceptible to injury.1 A cushioned running shoe heel reduces ground impact force during rearfoot striking, but it may also increase the plantar flexion moment at the ankle, thereby imposing a greater demand on the dorsiflexors.

CECS is a common problem encountered by running athletes (elite and recreational) and military personnel, which is often missed in the evaluation of exertional lower leg pain.2 The condition is characterized by recurrent discomfort over the anterior compartment of the lower leg that is induced by exercise and relieved by rest. The muscles are often acutely tender, the area may be described as feeling “tense” or “tight” and the runner may have difficulty controlling plantar flexion at heel-strike. A combination of pain and weakness may be manifested by forefoot ‘slaps’ against the running surface. The exact pathophysiology remains unclear, but it typically is attributed to elevated intracompartmental pressure from overuse of the anterior compartment muscles, which results in tissue hypoxia and subsequent ischaemic pain.3 The exact etiology and contributory factors are also not fully understood. Although these phenomena have not been conclusively linked to one another, eccentric contractions of the anterior compartment musculature have been associated with elevation of intracompartmental pressure and a reduction in compliance of the fascia surrounding the compartment.4

Because CECS is easily missed, patient evaluation should focus on acquisition of a detailed history and examination to exclude other potential causes of lower leg pain. Intracompartmental pressure testing is the most common method of confirming the diagnosis; however, the reliability of this procedure has been questioned, and there is a lack of consensus on the testing protocol and criteria for interpretation of the test results.5 After a diagnosis of CECS has been established, the patient may choose to discontinue the activity that produces its symptoms, try conservative management, or elect to have a surgical procedure performed. Conservative management involves rest, correction of structural misalignment with orthotics or corrective footwear, soft tissue massage, and stretching. Such procedures have been based primarily on case reports and expert opinion, and they rarely yield optimal outcomes.6 Surgical fasciotomy often produces satisfactory results, but possible complications include damage to the superficial peroneal nerve or saphenous
nerve, hematoma, infection, scarring, herniation, and recurrence of symptoms.\textsuperscript{7} Cessation of the precipitating activity is often perceived to be the best option by many sufferers.

Recent studies of barefoot running have demonstrated that some habitual barefoot runners land with a forefoot strike, but there is debate about the extent to which differences in the point of initial foot contact with the ground are explained by variations in surface hardness, speed, and distance.\textsuperscript{8-10} However, there is no debate about the fact that a forefoot strike fundamentally differs from a rearfoot strike. A rearfoot strike generates a rapidly developing high vertical ground reaction force when the heel makes contact with the running surface. In comparison, a forefoot strike does not generate this transient force. A recent study documented that college runners with a forefoot strike had an injury rate that was less than half that for runners who rearfoot strike.\textsuperscript{11} Although debate continues regarding the relative merits of running barefoot versus running in traditional shoes, as well as forefoot striking versus rearfoot striking, minimalist running shoes have become more popular over the past few years.

Forefoot striking has been associated with reduced anterior compartment pressure, but the association received minimal attention until very recently.\textsuperscript{12} There is now considerable interest in forefoot striking as a strategy for preventing or treating CECS. Significant reduction of intracompartmental pressure, increased running distance, and decreased pain have been documented as results of a 6-week intervention that involved instruction to promote adoption of a forefoot strike pattern among 10 CECS patients.\textsuperscript{13} The treatment program consisted of 3 sessions (45 min each) per week, which included activities designed to promote forefoot striking. The program was supervised by a physical therapist who utilized a metronome and video recordings to facilitate the transition from rearfoot to forefoot striking. Both subjective and objective improvements were documented at the 1-year follow-up session.

CECS can be considered a “biomechanical overload syndrome” that is precipitated by increased exercise intensity or frequency and altered biomechanics.\textsuperscript{14} Although a transition to forefoot striking may reduce CECS symptoms, it may elevate the risk of other injuries, such as Achilles tendinopathy and calf muscle strain. Therefore, transition from rearfoot to forefoot striking should be done gradually.

\section*{Conclusion}

Although only a single case has been reported and the determination of a positive outcome was purely based on the patient’s subjective experience, the transition from rearfoot striking to forefoot striking appeared to provide a profoundly beneficial effect. CECS remains a poorly understood phenomenon, but the success of the intervention seems to support a biomechanical basis for its symptoms. Emerging evidence suggests that forefoot strikers are less susceptible than rearfoot strikers to certain types of injuries, including a lower susceptibility to CECS.

\section*{References}


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