# Foot and Ankle Stress Fractures in Athletes

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**KEYWORDS**

• Stress fracture • Stress reaction • Foot • Ankle • Athlete

**KEY POINTS**

- Stress fractures of the foot and ankle are common in running and jumping athletes, and can result in significant disability and time away from sport.
- Bone scintigraphy and MRI are highly sensitive in evaluating athletes with suspected stress fracture, with the latter displaying higher specificity.
- Relative rest and gradual return to play is successful in treating most low-risk stress fractures.
- High-risk stress fractures often require operative treatment and can result in significant time away from sport.
- Bone stimulators and shock wave therapy have garnered significant interest, but have yet to be proved efficacious in the treatment of bone stress injuries.

## INTRODUCTION

### Epidemiology

Foot and ankle stress fractures are a major cause of disability in athletes of all types. Although the incidence of stress fractures in the general athletic population is less than 1%, the incidence may be as high as 15% in runners.[1] Stress fractures in military recruits have been studied extensively. The military recruit population is at particular risk because of the abrupt and rigorous nature of basic training. In a systematic review of the military literature, Wentz and colleagues[2] found a stress fracture incidence of 3% and 9.2%, in men and women respectively. The most common sites of stress fracture in both the military and athletic population are the leg and ankle. In a study of division I collegiate athletes over a 5-year period, the incidence of stress fracture was 1.4%. Foot, ankle, and tibia stress fractures were the most common, and sports with the highest rate of stress fracture were cross-country and track.[3] In a recent study of stress fractures in high school athletes, Changstrom and colleagues[4] reported a 0.8% incidence of stress fractures over a 7-year period, including more than 25 million athlete exposures. They reported a higher rate of stress fractures in women, and the lower leg and foot accounted for 40.3% and 34.9% of stress fractures respectively. Sports with the highest rates of stress fractures were girls' cross-country, girls' gymnastics, and boys' cross-country.

### Causes and Pathogenesis

Stress fractures of bone result from submaximal, repetitive loading resulting in an imbalance between bone resorption and formation. Athletes at highest risk are those who abruptly increase the duration, intensity, or frequency of physical activity without adequate periods of rest. These phenomena result in increased osteoclastic activity, leading to increased bone resorption and lagging bone formation. Ultimately the bone fatigues, and if there are intense and repetitive activities, microfractures may result. Stress injuries occur along a continuum, and a stress reaction is a bone stress injury resulting from microfracture without a defined fracture line on imaging. Continued stress to the bone results in

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coalescences of multiple microfractures, leading to a visible and defined stress fracture.[5–7]

Intrinsic and extrinsic factors affect the development of stress fractures. Intrinsic factors related to stress fractures include age, sex, bone mineral density, malalignment, hormonal imbalance, and poor vascular supply. Extrinsic factors are more easily modifiable and include activity type, intensity of training, training surface, improper technique or equipment, and poor nutrition.[8,9] Decreased bone mineral density has been correlated with increased stress fracture risk and may be related to diet, age, and hormone imbalance.[8,10,11] The female athlete triad (eating disorder, amenorrhea, and osteoporosis) refers to the phenomena most commonly seen in competitive female athletes involved in long-distance running, gymnastics, and figure skating. Barrack and colleagues[10] showed that the cumulative risk for bone stress injuries increased with increasing number of triad-related risk factors. Particular attention must be paid to these modifiable risk factors, and a dietary and menstrual history should be obtained when interviewing a female athlete.

### History, Physical Examination, and Imaging

Athletes presenting with foot and ankle stress fractures often describe a progressive and insidious onset of pain and swelling. A thorough history should include details on the athletes: intensity of training, duration of training, and changes in training surface or footwear. General medical information, including diet, nutrition, and in female athletes menstrual cycles, should be gathered. Physical examination focuses on weight-bearing alignment and range of motion. Areas of pain, tenderness, and swelling indicate areas of possible bone stress injury.

Imaging studies, including radiographs, computed tomography (CT), MRI, and bone scan, are helpful in evaluating patients for foot and ankle stress injuries. Initial and follow-up radiographs may be negative in as many as 85% and 50% of patients respectively.[12]

Bone scintigraphy is highly sensitive in evaluating bone stress injuries, and until the advent of MRI it was considered the gold standard.[13,14] Three-phase bone scan is recommended rather than other methods of bone scintigraphy because it allows differentiation between soft tissue and bony uptake. The sensitivity of bone scan is close to 100%, but it lacks specificity, with false-positive results possible with tumors, infections, and infarction.

MRI has become increasingly popular in the evaluation of bone stress injuries because of its high sensitivity and specificity. The added benefit of being able to evaluate the surrounding soft tissues for other pain-generating disorders makes MRI particularly attractive when evaluating patients with suspected bone stress injuries.[12,15] CT lacks the sensitivity of MRI, but is useful in defining fracture characteristics. The high-quality cross-sectional imaging produced with CT allows better definition of fracture lines, areas of sclerosis, and comminution.

### High-risk and Low-risk Stress Fractures

Stress fractures can be categorized as either high risk or low risk based on their propensity to heal. High-risk stress fractures have a greater risk of complete fracture or nonunion, and often require prolonged periods of non–weight-bearing immobilization or surgical treatment. Stress fractures, including navicular, medial malleolus, talus, hallucal sesamoid, and proximal fifth metatarsal, are considered high risk. Low-risk stress fractures, such as calcaneus, lateral malleolus, and metatarsal shafts, are generally treated successfully with relative rest and symptomatic relief. Patients with low-risk stress fracture typically make a full recovery without long-term adverse effects.[5,6,16]

## LOW-RISK STRESS FRACTURES

### Fibular Stress Fractures

Fibular stress fractures are rare in the athletic population. These fractures, termed runners fractures, are most commonly seen in running athletes. In a study of 320 athletes, stress fractures of the fibula accounted for 6.6% of all stress fractures.[17]

Stress fractures of the fibula may occur along the entire length of the fibula, but are most commonly seen in the distal third in the athletic population. In Burrows'[18] study of fibula stress fractures, he noted that most fractures in runners occurred in the cortical area of the distal fibula just proximal to the syndesmotic ligaments, approximately 50 mm (2 inches) or more above the tip of the malleolus. In a later study of 50 fibular stress fractures in athletes, Devas and colleagues[19] reported similar findings, with the most common location of fracture being 4 to 7 cm above the tip of the lateral malleoli (Fig. 1).

Fibula stress fractures are thought to result from a combination of muscular forces and repetitive axial loading. Axial force transmission through the fibula during weight-bearing activities varies between 2.3% and 10.4% depending on ankle position and limb orientation.[20] Muscular forces during running are thought to play a role in fibular stress fractures; namely,