

## Stress Fractures

Stress fractures comprise between 0.7 and 15.6 percent of all athletic injuries. Athletes particularly at risk of stress fracture are runners and jumpers, gymnasts and dancers. Stress fracture incidence among U.S. military recruits is also high, ranging from approximately one to 20 percent, with higher rates reported for women than for men. In general, the bones most commonly injured are the metatarsals, fibula and tibia.

### Etiology

Normal physiological loading provokes a range of deformation reactions (strains) in bone, including compression, tension, shear, torsion, and vibration. Bone exhibits an intrinsic ability to adapt to alterations in chronic loading to withstand future loads of the same nature, a phenomenon commonly referred to as Wolff's Law. Adaptation of bone to load changes occurs via increased modeling and/or remodeling. Modeling is a process whereby bone tissue is either deposited or removed to modify the shape and size of a bone. Remodeling describes a process of bone resorption, followed (after a delay of roughly one month) by deposition of new bone (for approximately six months). While some level of remodeling is constantly occurring in normal bone, in bone undergoing adaptation to altered loading, the degree of remodeling increases substantially. The initial increase in resorption will render a bone relatively porous until the process of deposition can replace the lost tissue in full. During this prolonged replacement phase, bone is more susceptible to stress fracture by virtue of increased porosity.

### Risk Factors

The following factors contribute to the incidence of stress fracture either directly or indirectly via their influence on bone strain and commensurate relationship to bone remodeling:

- Training changes (e.g. terrain, shoes, activity, training intensity)
- Running and jumping activities
- Inappropriate footwear
- Muscle inflexibility
- Muscle weakness
- Excessive muscle strength
- Lower extremity alignment anomalies
- Poor running technique
- Previous history of injury
- Low bone mineral density (in women, often secondary to inadequately circulating estrogen.)

### Diagnosis

Positive symptoms of stress fracture include local tenderness, pain with direct and/or indirect percussion and pain with weight bearing, (particularly hopping on the affected limb.) Signs of swelling at the injury site may be present. Confirmation of clinical diagnosis may be obtained via triple-phase Technetium 99 bone scans (often considered the standard diagnostic tool), and magnetic resonance imaging (MRI). Plain x-rays are normally inadequately sensitive for the purposes of early diagnosis. Generally, historical symptoms and physical signs are enough for diagnosis.

### Management Recommendations

Because stress fractures are pathological expressions of the normal adaptive response of bone to modified loading, unloading (rest) remains an effective treatment under most conditions.

Prevention is, however, undoubtedly the best management approach. Coaches must be cognizant of stress fracture risk factors when designing training programs.

Recommendations that minimize the risk of stress fracture and promote recovery include the following:

**DURING training:**

- Wear lightweight, activity-specific athletic shoes and replace them after approximately 500-700 kilometers of running.
- Increase training intensity gradually over a period of weeks, introducing hills, interval training, jumping exercises and high-strain, sport-specific activities only after approximately six weeks of graduated training.
- If various surfaces will be encountered during training and competition, begin training on surfaces that absorb shock well, such as level asphalt. Then progress to man-made track, grass, sand or uneven terrain, thereafter varying the training surface.
- Maintain adequate dietary calcium intake (at least 1200 mg/day for those younger than 25 years; 800mg/day for those older) to allow healthy bone mineralization during remodeling.
- Female athletes should maintain normal concentration of circulating estrogen, using menstrual dysfunction as a warning flag.

**When INJURED:**

- Maintain aerobic fitness when injured via reduced weight-bearing exercise such as pool running and bicycling
- Resume training gradually, incorporating pool running during the latter stages of healing and early stages of return, building rest days into the regimen. Ask for light-intensity training guidelines from your therapist or exercise physiologist.
- If a particularly fast return to activity is necessary, use protective devices, e.g. a pneumatic tibia brace, to splint bones from strain during weight bearing.

**DO NOT:**

- Excessively stretch adjacent muscles when acutely injured,
- Perform local muscle-strengthening exercises when acutely injured,
- Engage in pain-producing activities when injured
- Train on unusually soft or uneven surfaces when injured

**New directions**

Preliminary evidence suggests that the application of electric and electromagnetic fields or sound waves may enhance the healing of stress fractures. A number of bone stimulatory devices are currently on the market, and research in the field of stress fracture application is ongoing.

**Summary**

Stress fractures are a recognized complication of the chronic, intensive, weight-bearing training familiar to athletic, dance and military populations. Bones are most susceptible to stress fracture when weakened by remodeling-related porosity, a primary stage in the adaptive response of bone to changes in patterns of loading. Prevention is the most appropriate management approach, best achieved through graduated training increments. The goal of stress fracture treatment is to facilitate the natural progression of bone remodeling by reducing loads on the injured site to the greatest extent. Thus, rest from pain-provoking activities remains the most effective, if often prolonged, intervention approach at this time.

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