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Imaging of Stress Fractures in Runners

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Running is an extremely popular form of exercise. The emphasis today on the importance of exercise and weight loss and the convenience and low cost of running as a form of exercise have undoubtedly led to this popularity. Running-related injuries are common, however, and the current focus on the importance of health, diet, and fitness as well as competitive athletics has resulted in many individuals undertaking new or increasing levels of physical activity. This results in increasing levels of stress on the musculoskeletal system. Stress fractures in runners are a common problem, but the diagnosis and treatment is often challenging. Health care providers caring for recreational and professional athletes must be knowledgeable of the signs and symptoms of these injuries and maintain a high suspicion when seeing active patients seeking care for lower extremity and axial skeletal pain, because the signs and symptoms are often vague and overlap with other diagnoses.

PATHOPHYSIOLOGY

There is a spectrum of osseous stress injuries that occurs, beginning with stress reaction or stress response and eventually leading to stress fracture. The pathophysiology of stress reaction and stress fractures is related to the bone response to the repetitive stresses at the cellular level. With excess stresses, the osteoclasts replace the circumferential lamellar bone with dense osteonal bone. This is accompanied by the development of edema and hyperemia, which is the stress reaction or stress response that can be demonstrated by MRI. The relative muscle groups, which are also experiencing the repetitive stresses, respond with hypertrophy and strengthening more rapidly than bone, and this force is transmitted to the periosteum at the muscle attachments, resulting in periostitis. Stress fractures are microfractures of bone that result from repetitive physical loading of the involved bone, which can lead to complete fractures if the excessive stress on the bone continues [1,2].

Stress fractures fall into two general categories: fatigue stress fractures and insufficiency fractures. Fatigue stress fractures result from the exposure of

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normal bone to excessive repetitive stress. Fatigue stress fractures tend to be seen in a young, active, healthy population such as recreational and professional athletes and members of the military. Insufficiency fractures tend to occur in bones that are predisposed to fracture based upon osteopenia and osteoporosis, and these conditions are more commonly seen in the elderly population or in patients who have secondary causes of demineralization [3].

Most stress fractures occur 4 to 5 weeks after the onset of a new exercise. Muscles normally provide biomechanical dissipation of stress from the bones, but fatigued muscle may decrease this protective contribution, and this can result in the transmission of increased stress to the bones [4]. The incidence of stress fractures increase with advancing age [5]. The location of stress fractures in runners tends to also vary with age, with femoral and tarsal stress fractures occurring in older patients, and fibular and tibial stress fractures occurring in the younger athlete [6].

Runners are particularly at risk because of the multitude of factors that can result in the increased or altered stressors to the skeletal system. Stress fractures occur in 13% to 37% of runners [7]. There is a decreasing incidence of these fractures in the tibia (33%), navicular (20%), metatarsals (20%), femur (11%), fibula (7%), and pelvis (7%); in 75%, the medial tibial crest is involved [8]. Factors found to be associated with stress fractures include training errors, distance, age, running surfaces, shoes, diet factors such as malnutrition and anorexia nervosa, smoking, alcohol use, a history of overuse injuries, and hormonal alterations such as amenorrhea, inhaled corticosteroids, and hypothalamic dysfunction [7–11]. Certain biomechanical factors have been found to be associated with patients experiencing multiple stress fractures. These include a high longitudinal arch of the foot, leg-length inequality, and excessive forefoot varus. Females who have menstrual irregularities seem to have an increased risk of recurrent stress fractures. Runners who have high weekly training mileage have also been found to have an increased risk of recurrent stress fractures of the lower extremities [12].

BIOMECHANICS OF RUNNING

A discussion of running-related injuries necessitates a brief summary of the biomechanics of running. During running, each foot strikes the ground 50 to 70 times per minute for each foot. The force produced is two to four times the runner's body weight. This force is distributed through the runner's footwear, and transmitted upwards through the lower extremities and into the pelvis, sacrum, and spine, exposing these structures to increased axial stresses. There are two main phases of running: the support and airborne phases. The support phase consists of the heel strike, midstance, and toe-off. The airborne phase consists of the follow-through, forward swing, and descent. There are complex motions of the subtalar joint and other joints of the lower extremity during these phases. At heel strike, there is dorsiflexion and supination of the foot, and slight external rotation of the tibia. Following heel strike, the foot pronates during approximately 60% of the midstance phase, and there is internal rotation of the tibia