Osteopenia and Osteoporosis in Female Athletes

John M. MacKnight, MD

KEYWORDS

• Osteopenia • Osteoporosis • Low bone density • Athlete • Sports medicine

KEY POINTS

- Low bone mass manifest as osteopenia or osteoporosis is common in the general population and especially common in female athletes.
- Exercise is an important stimulus to bone formation, but when done to excess may impact negatively on bone health as both a young and older woman.
- Attention to optimizing maximal bone mass development as an adolescent and young adult is crucial to establishing lifelong bone health for women.
- Bone health is positively influenced by a number of lifestyle measures; it should be every care provider's goal to optimize these important factors for women throughout their lives.

Disorders of bone density are common in the general population and especially prevalent among athletic women.[1] The severity of bone loss is variable and ranges from milder degrees of bone loss, termed osteopenia, to more profound degrees of loss resulting in frank osteoporosis. More than half of US adults older than 50 years have low bone mass at the femoral neck or lumbar spine, and nearly 10% meet the diagnostic criteria for osteoporosis at one or both sites.[2] In female athletes, there is a higher incidence of osteoporosis due to a decreased rate of bone accretion in youth, which in turn results in a lower peak bone mass, especially in those with delayed menarche.[3] Low bone mass poses a particular challenge for athletes because it not only predisposes to stress-related bone injuries but also sets the stage for increased risk of osteoporosis and insufficiency fractures with aging.

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Internal Medicine, University of Virginia Health System, University Physicians-Charlottesville, 415 Ray C. Hunt Drive, Suite 2100, Charlottesville, VA 22908, USA
E-mail address: jm9m@virginia.edu

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This article reviews the pathophysiology of bone thinning in both premenopausal and postmenopausal women, the impact of exercise on these processes, and the treatment options presently available. It should be every provider's goal to proactively identify at-risk individuals to prevent major bone metabolic issues before they arise. For women who already demonstrate bone thinning, the collective goal must be to correct present deficiencies, modify future osteoporosis risk, and preserve the desired level of activity.

NORMAL BONE METABOLISM

The adult human skeleton is composed of 2 types of bone. Cortical bone accounts for roughly 80% of overall bone mass and is dense, solid, and surrounds the bone marrow space. Trabecular or cancellous bone is a honeycomblike network of trabecular plates and rods throughout the bone marrow compartment[4] that makes up the remaining 20%. Bone is a dynamic tissue that is involved in a constant remodeling process of formation and resorption.[5–7] Bone remodeling is initiated at the cellular level by osteoclasts that contain enzymes that dissolve the bone surface and drive the resorption process. To compensate for bone breakdown, osteoblasts initiate bone formation by secreting osteoid, the bone matrix protein, which then mineralizes to complete the bone formation process.[5,8] The most crucial time in this process for maximum gains in peak bone mass and the development of long-term bone density is in adolescence and early adulthood. Healthy girls experience a peak period of bone mass accrual typically between ages 11 and 14 years,[9] with nearly 90% of peak bone mass attained by the age of 18.[10] Increases in growth hormone, insulinlike growth factor 1, and estrogen that occur between Tanner stages 2 and 4 coincide with these maximal rates of bone mineral gain. Despite strong genetic determinants of individual bone mineral density (BMD), it is during this critical time that a number of intrinsic or extrinsic factors may play a negative role in the achievement of maximal bone mass as well. These factors will be addressed later in this article.

After maximum bone mass is achieved by approximately age 35 years, the remodeling process becomes uncoupled and bone density begins a slow and steady decline that may eventually lead to osteopenia or osteoporosis.[11–15] The preservation of bone density and the ability to perform athletically over time are a direct result of optimizing bone deposition early in life and minimizing this inevitable decline in bone density, especially after menopause. It is estimated based on present data that achieving a 10% higher peak bone mass in young adulthood may delay the development of osteoporosis by approximately 13 years, and ultimately reduce the lifetime risk of fracture by 50%.[16]

IMPACT OF SPORT AND EXERCISE ON BONE HEALTH

Sedentarism is associated with the risk of developing osteoporosis. Physical activity is the only lifestyle measure that increases bone mass and strength while also reducing the risk of falls later in life. Bone responds to mechanotransduction, a process by which bone recognizes mechanical loading through mechanoreceptors in osteocytes. Osteogenic, bone-forming, stresses are variable, dynamic, and progressive; static exercise loading does not cause osteogenesis.[17] In children and adolescents, mechanical loading of bone through physical activity is essential for maximal bone density acquisition. The benefits seen in childhood and adolescence continue into adulthood and are important for the maintenance of bone density with aging.[18–21] As such, the recommendation of exercise for the prevention of osteoporosis later in life should