Bone Mineral Density in the Reproductive-Age Woman

Effects of Medications, Pregnancy, Lactation, and Exercise

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Abstract

Multiple factors affect the attainment and preservation of bone mass throughout the reproductive years of a woman’s life, although the immediate effects of these factors may not be apparent in younger women. Exercise, contraceptives, gonadotropin-releasing hormone agonists, hormonal breast cancer treatments, pregnancy, and lactation may all affect pre- and postmenopausal bone mineral density. Sedentary adolescent females should be counseled about appropriate exercise and its lifelong importance in bone health. Athletes should be carefully screened for components of the female athlete triad. When prescribing contraception, factors such as formulation, patient age, and menstrual history should be taken into consideration, as these factors can affect bone density. Clinical use of gonadotropin-releasing hormone agonists should remain limited because of significant bone loss associated with their use. Because premenopausal tamoxifen use and aromatase inhibitors affect fracture risk, patients should be carefully selected prior to the use of these drugs. Although pregnancy and lactation induce metabolic changes that may seem deleterious to bone, lasting effects are not generally apparent. This article presents a review of the factors currently implicated in the maintenance of bone health in premenopausal women.

Key Words: Bone mineral density; exercise; female athlete triad; contraception; oral contraceptives; medroxyprogesterone acetate; leuprolide acetate; gonadotropin-releasing hormone agonist; tamoxifen; aromatase inhibitor; anastrozole; letrozole; exemestane; pregnancy; lactation.

Introduction

Multiple factors affect the attainment and preservation of bone mass throughout the reproductive years of a woman’s life, although immediate effects of these factors may not be apparent in younger women. Exercise, contraceptives, gonadotropin-releasing hormone agonists, hormonal breast cancer treatments, pregnancy, and lactation may all affect pre- and postmenopausal bone mineral density (BMD).

Although there are many studies looking at BMD in premenopausal women, those assessing fracture risk are limited because of lower fracture rates in this population. The consequence of low bone mass in young women may be an increased risk of postmenopausal fracture. This article presents a review of the factors currently implicated in the maintenance of bone health in premenopausal women.

Exercise

Exercise is osteogenic. When stress is applied to a given area of bone, mechanical strain is produced and bone modeling is stimulated. Mechanical loading forces that are applied to bone in a novel
and dynamic fashion result in the greatest bone-formative effect (1). Local muscle mass and muscle strength are also correlated with BMD; thus the direct influence of skeletal muscle on bone seems to be important for the development and maintenance of bone mass (2). The developing skeleton is uniquely sensitive to the effects of exercise (3,4) and regular bone-loading exercise is an important contributor to the acquisition of peak bone mass (5). Subjects enrolled in the Penn State Young Women’s Health Study demonstrated increased adolescent bone gain and peak hip BMD with daily weight-bearing exercise (6). After 10 yr of follow-up, exercise during adolescence was the only variable significantly associated with increased bone density and calculated bone-bending strength (7). Plyometric jump training and sport-specific training during adolescence and young adulthood has similarly shown positive effects on BMD (8,9). Interestingly, inactive women who report post-high school sports participation have demonstrated significantly higher T-scores at the femoral neck as adults (10).

Exercise across the life span is a key component of bone health. Adult premenopausal exercisers demonstrate increased lean mass when compared with sedentary controls; those exercising with higher impact have greater leg strength and higher whole-body and regional BMD (11). Although nonimpact or low-impact regular exercise may have other benefits, when it comes to bone, the higher the impact, the greater the effect. Eumenorrheic athletes in the highest impact and jumping sports have the highest BMD in weight-bearing areas and demonstrate the highest levels of bone-formation markers (12).

In addition to the beneficial effects of repetitive weight-bearing exercise on the skeleton, there exists a positive association between BMD and resistance (i.e., strength, weight) training. Novel strength training introduced to postmenopausal women positively affects BMD, and the effect at specific sites correlates with the cumulative amount of weight lifted (13). Sedentary women tested after a bout of cycling or running show significant, acute increases in serum alkaline phosphatase, phosphate, and parathyroid hormone, suggesting that repetitive strenuous exercise does indeed influence bone formation acutely (14). Strength training is beneficial; animal studies have suggested that this type of lower magnitude, higher cycle loading does not adversely affect mechanical properties of the tibia or adversely affect bone resorption (15).

Asikainen et al. recently published an extensive, systematic review of randomized controlled trials investigating the effects of exercise on bone health in early premenopausal women (16). Based on their analysis of the accumulated data, a safe and effective program designed to preserve BMD and increase strength in this population should generally include both repetitive weight-bearing exercise, such as walking, and some sort of resistance training. Women should walk daily at a moderate pace for at least 30 min. Exercise sessions can be continuous or may be divided into two or three shorter bouts of activity. Resistance training should be performed at least twice a week and should encompass 8 to 10 large muscle movements repeated at least 8 to 10 times. The weight lifted can commence at 40% of one repetition-maximum (the maximal weight that can be lifted with proper technique one time). Even women new to exercise can comfortably adopt such a program with the proper guidance and encouragement.

Highly trained and elite female athletes demonstrate increased BMD in loaded regions; however, the effect of high levels of activity on bone can be detrimental (17–19). The literature consistently supports the contention that the osteogenic effects of exercise are modulated in a complex manner by the nutritional and hormonal status of the athlete (20–23). For example, female, elite-level winter sports athletes with normal menstrual function have higher BMD compared with age- and body mass-matched controls, a difference that remains significant after controlling for lean mass. However, athletes with a history of oligo- or amenorrhea seem to lose the osteogenic benefit of their sports participation and demonstrate similar BMD as eumenorrheic, nonathletic controls (24). This effect has been seen in dancers and gymnasts as well. Amenorrheic dancers more often report delayed menarche and a higher incidence of dieting behaviors than eumenorrheic dancers, they demonstrate significantly lower BMD over time, and they may have an increased risk of stress fracture as well (25). Collegiate female gymnasts have higher BMD at all sites prior to and during the competitive season than runners, despite a greater reported prevalence of menstrual dysfunction.