Diet for the heart or the bone: a biological tradeoff

Susan M Ott

Skeletal strength is determined by several interactive factors, including hereditary background, race, sex, weight, hormones, physical activity, and nutrition. Most of the research on the nutritional component has focused on individual nutrients, especially calcium. Whereas calcium may be the single most important nutrient, others are also influential. The report by MacDonald et al (1) in this issue of the Journal focuses on several nutrients that may either benefit or harm the skeleton. Those authors evaluated dietary intakes in a prospective observational study of perimenopausal women and found a positive effect of calcium and ethanol on bone density. They also showed a negative effect of fatty acids. In the women who were still menstruating, the intake of fruit and vegetables was associated with higher bone density.

The authors realized that their observed associations could not determine causation, and they discussed clearly the potential mechanisms for the nutrients that played a role in skeletal metabolism. Fruit and vegetables contain several nutrients that could benefit bone. The role of the skeleton in acid-base balance is often unrecognized. Bones serve as a reservoir for both minerals and bicarbonate, and acidosis stimulates bone resorption. Mild acidosis could explain some of the gradual loss of bone density in elderly persons, in whom the kidneys can no longer completely compensate for nutritional fixed acid production. In the study by MacDonald et al, however, the benefits were seen only in the younger women, and thus it is clear that other reasons or interactions are also involved in this association.

Magnesium is present in fruit and vegetables, but the role of this mineral is not clear. Parathyroid hormone can be either stimulated or suppressed by magnesium deficiency, depending on the severity of the deficiency. There have been no well-designed clinical trials of the effect of magnesium on bone density. A large observational study of 89,717 women conducted by the Women’s Health Initiative, published to date in abstract form only, indicated that the women in the highest quintile of magnesium intake had an increased risk of forearm fracture and lacked an effect of protection against other clinical fractures (2).

The study found negative effects of fatty acids. These nutrients have not been evaluated as extensively for their effect on the skeleton as have other nutrients, and the mechanism of action is unknown. Bone density and serum concentrations of osteoblast markers decreased in mice fed a high-fat diet. Further studies suggested that marrow cells were more likely to differentiate into adipocytes than into osteoblasts when exposed to minimally oxidized LDLs. Abnormal lipid concentrations may contribute to the pathogenesis of osteoporosis (3).

Thus, in relation to single nutrients, it appears that foods that are good for the heart are also good for the bones. Ethanol, fruit, and vegetables are beneficial for both systems, whereas fatty acids have adverse effects on bone. Consideration of total energy intake, however, suggests a different view. In the study by MacDonald et al, the associations between nutrients and bone density were adjusted for total energy intake. This is an appropriate analysis when the focus is on individual nutrients or food types. Although those authors did not discuss the effect of total energy intake, the data showed that the annual percentage weight change was significantly associated with bone density. Whereas increased weight benefits the bones, it is a risk factor for heart disease.

Body weight is one of the most significant factors that determines bone density and fracture risk. A recently presented meta-analysis, published to date in abstract form only, involved 45,000 persons from 9 prospective cohorts and found, with the use of a body mass index (BMI; in kg/m²) of 25 as reference, that the relative risk of hip fractures increased from 0.52 in severely obese persons with a BMI of 40 to 4.18 in thin persons with a BMI of 15. Those with a BMI of 20 were twice as likely to fracture a hip as were those with a BMI of 25 (4). There are several plausible mechanisms for these findings. Adipocytes contain aromatase, which can increase estrogen concentrations, and estrogen is without doubt beneficial to skeletal strength. Adipocytes also excrete leptins and other hormones involved in weight regulation, but the effects of these hormones on the skeleton are still controversial. Bones respond to mechanical loading, and heavier persons place more stress on the bones. The padding function of the fat also serves to protect against fractures.

Change in body weight is also significantly related to bone density and fracture rates. In the Study of Osteoporotic Fractures, which followed 9516 women aged >65 y, the change in weight from the women’s self-reporting of their weight at age 25 y to the current weight was significantly associated with the risk of hip fracture. Those in the lowest quintile of weight...
change (those who lost >10% of body weight) had 15 fractures per 1000 women per year, whereas those in the highest quartile of weight change (those who gained >50% of body weight) had only 2 fractures per 1000 women per year (5). A clinical trial of weight loss in overweight postmenopausal women found a significant correlation between the loss of weight and the loss of total-body bone density (6). In the Women’s Healthy Lifestyle Project, 236 healthy women aged 44–50 y participated in a clinical trial in which they were randomly assigned to a low-fat diet. The trial was successful in terms of weight loss: the intervention group lost 3.2 kg, whereas the control group gained 0.4 kg. The group that lost weight, however, also lost bone density at the hip at the rate of 0.8%/y, which was twice the rate of loss in the control group (0.42%/y; 7).

These studies illustrate a biological tradeoff between the cardiovascular system and the skeletal system. Obesity and osteoporosis are both common chronic conditions that result in poor quality of life. The ideal body weight must be a compromise between an obese weight that is best for the skeleton and a thin weight that is best for the heart. Dietary recommendations that are appropriate for persons with a high BMI will not be sufficient for thin persons, who are at a greater risk of fracture. In my osteoporosis clinic, I frequently see thin women who are surprised to discover that their “healthy” low-fat, high-vegetable diets are not protecting them from bone loss. The recommended diets must be tailored to the risks of each person. For bone health, it is important to consider the effects of the total amount of energy intake as well as the effects of the individual nutrients and how these both interact with hormonal changes and physical activity. Further research is needed to understand how to achieve the optimal balance between cardiovascular and skeletal health.

REFERENCES