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Fruit and vegetables: the unexpected natural answer to the question of osteoporosis prevention?[1,2]

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We are in an epidemic of osteoporosis. There can be no doubt about that. Global estimates for 2006 are that 1 in 3 women and 1 in 10 men now aged ≥55 y will have osteoporosis in their lifetime. In the United States, 10 million Americans have osteoporosis, and costs are estimated at $17.9 billion annually. In the United Kingdom, 3 million persons are affected, and the estimated costs for all of Europe are in excess of €13.9 billion (euros) annually. We urgently need public health strategies to maintain bone health throughout the life cycle and to prevent osteoporosis in later life.

The evidence base for the disease-preventing benefits of high intakes of fruit and vegetables continues to expand with respect to ischemic heart disease; stomach, bowel, and breast cancer; and, most recently, stroke (1). The message "eat your fruit and vegetables" is a sensible one (2); the only debate is about the recommended number of portions. For osteoporosis, the evidence from a combination of observational, experimental, clinical, and intervention studies strongly points to a positive link between fruit and vegetable consumption and indexes of bone health.

In this issue of the Journal, Prynne et al (3) report the findings of a cross-sectional study examining the association between fruit and vegetable consumption and bone mineral status in 5 age and sex cohorts. Intriguingly, the results indicate significant positive associations between fruit and vegetable intakes and both spine size-adjusted bone mineral content and whole-body bone mineral density in adolescent boys and girls aged 16–18 y. In the older women, aged 60–83 y, significant positive associations were found between spine size-adjusted bone mineral content and fruit intake. The size of the effect in the older women was impressive: doubling the fruit intake would have resulted in a 5% increment in spine bone mineral content.

The particular strengths of this study are the rigorous method used to assess fruit and vegetable consumption; the study analyzed the actual portion weights of fruit and vegetables, rather than analyzing the frequency of dietary intake of these 2 food groups or relying on past consumption data. Furthermore, the bone data were carefully adjusted for body size, which is a particular problem with the standard areal-density measurement (g/cm^2) that is routinely collected by using dual-energy X-ray absorptiometry.

The association between fruit and vegetable consumption and indexes of bone health was first identified within the older population (4-6), and more recent studies have shown the link in relation to peak bone mass acquisition. Jones et al (7) were the first to report a positive link between fruit and vegetable consumption and bone density in young adolescent females. Tylavsky et al (8) showed fruit and vegetable intakes to be a significant independent predictor of bone area and bone mineral density in 56 girls aged 8–13 y. McGartland et al (9) found that a greater fruit intake was associated with higher heel bone mineral density in girls (but not boys) aged 12 y, and Vatanparast et al (10) found that fruit and vegetable intakes were significant independent environmental predictors of total-body bone mineral content in boys (but not girls) aged 8–20 y.

Associations observed in observational studies do not indicate causality, but interest is growing about a potential mechanism involving dietary influences (ie, an alkalizing effect of fruit and vegetables) on acid-base balance. Moreover, an important role for the skeleton in acid-base homeostasis, where it acts as a source of "buffer," contributing to both the preservation of the body's pH and the defense of the system against acid-base disorders, has been known for more than 3 decades. Crucially, natural, pathologic, and experimental states of acid loading or acidosis are associated with hypercalciuria and negative calcium balance, and detrimental effects of "an acid environment" on bone mineral density have been shown in the elegant work of Arnett and Dempster (11) and Bushinsky et al (12). Seminal work by Sebastian et al (13) showed that the administration of base as potassium bicarbonate resulted in both a decrease in urinary calcium and phosphorus excretion and an improvement in overall calcium balance, which was accompanied by a decrease in urinary excretion of hydroxyproline (bone resorption) and an increase in serum osteocalcin (bone formation).

What are now needed urgently are randomized controlled trials to confirm the benefit of fruit and vegetables to the skeleton and to identify the extent of that benefit. A 3-mo Dietary Approaches to Stopping Hypertension (DASH) intervention study involving 23–76-y-old men and women showed convincingly that a diet high in fruit and vegetables significantly reduces bone turnover (14).

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Whereas the alkalizing effect of fruit and vegetable consumption has drawn attention as a possible mechanism of their beneficial influence on bone, other plausible mechanisms include the dietary influence of vitamin K, phytoestrogens, and as yet unidentified dietary components acting in concert, in which case the sum of the effect is greater than that of the parts. Vegetables, herbs, and salads that are commonly consumed in the human diet have been shown to affect bone resorption in rats by a mechanism that is not mediated by their base excess but that may be mediated through pharmacologically active compounds.

We currently have more questions than answers. Future research should focus attention on, first, long-term intervention trials centered specifically on fruit and vegetable intakes or alkali administration as the supplementation vehicle and assessing a wide range of bone health indexes (including fracture risk) and, second, experimental studies (at the cellular, animal, and human levels) to ascertain whether other aspects of fruit and vegetables are beneficial to bone metabolism and under what mechanisms (15).

If these questions can be answered, a "fruit and vegetables" approach may provide a very sensible (and natural) alternative therapy for osteoporosis treatment, one that is likely to have numerous additional health-related benefits. However, persuading Western populations to increase their fruit and vegetable consumption remains our biggest challenge.

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