Panel Session: Nutrition/Exercise

Panel Summary

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THIS PANEL discussed two major behavioral factors that influence the risk for osteoporosis—nutrition and exercise. Although the most important risk factors for osteoporosis appear to be aging and menopause, there is little at present that can be done to counteract the effect of aging, and, as discussed by the panelists, estrogen replacement therapy has both risks and benefits. Nonetheless, nutrition and exercise are important factors because they are relatively easy to manipulate, and thus fit well into a national public awareness campaign aimed at reducing the incidence of osteoporosis in future generations. These factors were reviewed and discussed in detail by the four speakers.

Dr. Robert P. Heaney of Creighton University discussed the possible role of calcium intake in the pathogenesis of osteoporosis. This is one of the most important, but also the most controversial, areas in osteoporosis research. As Dr. Heaney points out, some of the controversy arises from a lack of understanding about two general principles. First, calcium is a threshold nutrient, meaning that deleterious effects occur only below a certain level of intake. Second, osteoporosis is a multifactorial disorder. Thus, calcium deficiency may be only one of a number of factors that may induce bone loss, and its importance may vary considerably among individuals.

There is no doubt that calcium deficiency can induce osteoporosis. This has been clearly demonstrated in experimental animals. In contrast to many nutrients, such as sodium, potassium, and phosphate, calcium is poorly conserved by the body when intake is decreased. Obligatory losses of calcium from the body must be offset by an equal amount of absorbed calcium. If such an offset does not occur, calcium will be withdrawn from bone, which contains 99 percent of the body's reserves. Normal adults adapt to decreased calcium intake mainly by increasing the fraction of dietary calcium absorbed, but adaptation is impaired by menopause and by the aging process. The minimal dietary calcium intake that is required to prevent bone loss in humans has not been rigorously established, but the Recommended Daily Allowance in the United States is currently 800 milligrams (mg) per day. The second National Health and Nutrition Examination Survey (conducted under the auspices of the U.S. Public Health Service from 1976 to 1980), however, showed that the average dietary intake of middle-aged and elderly women was only 550 mg per day, and one-third of those surveyed had very low intakes, less than 400 mg per day. Using calcium balance methodology, Nordin et al. (*1*) found that calcium intake was only 550 mg per day for a group of predominantly young adults. By contrast, Heaney et al. (*2*), also using calcium balance methods, estimated the calcium requirement to be 1,000 mg per day for premenopausal women, and 1,500 mg per day for postmenopausal women. In his presentation, Heaney stated that these data have been recently reviewed and confirmed. Further, he found that three-quarters of perimenopausal women had a level of intestinal calcium absorption that, on a dietary calcium intake of 800 mg per day, would be inadequate to compensate for losses of calcium in urine and feces.

Few epidemiologic studies have related calcium intake to bone density. Some of these have shown a weakly positive correlation. Clinical trials of calcium supplementation are difficult to interpret, because they have been conducted primarily in women soon after menopause. In such women, estrogen deficiency induces a transient phase of accelerated bone loss. But, as Heaney pointed out, calcium supplements are not likely to correct this entirely. Most of the relevant studies have reported that, although calcium supplementation retarded bone loss, particularly from the cortical bone of the appendicular skeleton, the therapeutic effect was less striking than that for estrogen replacement. A recent study (*3*) suggests that concomitant administration of calcium reduces the dosage of estrogen required to prevent bone loss.

While awaiting the results of ongoing prospective

studies, a reasonable course to follow would be the recommendations of the 1987 National Institutes of Health Workshop on Research Directions in Osteoporosis. The workshop recommended that all adults have a minimal daily intake of 1,000 mg of calcium, which can be reached by dietary means alone. Such advice is reasonable, and can be approximated by consuming a normal American diet, plus three exchanges of dairy products per day. For example, one exchange would be about equivalent to a glass of milk, a dish of ice cream, a thick slice of cheese, or a small container of yogurt. Calorie-conscious individuals should note that skim milk or low-fat milk products contain even more calcium than do whole milk products. Children, adolescents, and pregnant women should consume 1,500 mg per day. Persons with osteoporosis, or judged to be at increased risk of osteoporosis, should consume at least 1,500 mg of calcium per day.

Other nutritional factors seem to be less important than calcium. A high protein intake increases urinary excretion of calcium, and may increase the amount of dietary calcium required to maintain balance.

Dr. R.F. Shangraw of the University of Maryland reviewed factors that are important in the selection of a calcium supplement. Owing to the increased awareness of osteoporosis, there has been an exponential increase in sales of calcium supplements in a wide variety of calcium products. For example, between 1982 and 1986, sales of calcium tablets increased from approximately $25 million to $250 million annually. Calcium supplements are the most practical way to reach calcium intakes above 1,000 mg per day. In addition, some women have difficulty digesting milk products because of lactose intolerance. For those of limited income, calcium supplements are a cheaper way to reach higher levels of calcium intake than milk products (however, supplements do not provide other nutrients, as do milk products). Of the various calcium salts, calcium carbonate and calcium phosphate have been the most popular because of their relatively high content of elemental calcium per tablet. Nonetheless, these salts are poorly absorbed in the absence of hydrochloric acid in the stomach, and about 10 percent of elderly individuals have achlorhydria. Because there is more hydrochloric acid present in the stomach during and following meals, this is the preferred time to take dietary calcium supplements, rather than on an empty stomach.

Dr. Shangraw reported the shocking finding that 18 of 35 over-the-counter calcium supplement products failed the old "U.S. Pharmacopeia" disintegration test (*4*) (they did not dissolve in dilute hydrochloric acid within 30 minutes). This does not mean that the calcium in these products does not have some bioavailability, but it will probably be poorly absorbed. Government regulatory bodies need to address this important issue.

Dr. Charles H. Chesnut of the University of Washington addressed the important problem of the role of nutrition in maintaining bone health in adolescence. The majority of bone in the body is laid down during the relatively few years of the adolescent growth spurt. By the end of linear growth at about 18–20 years, the skeleton continues to fill out, and an additional 10 percent of bone mass is added during the subsequent decade, the so-called phase of skeletal consolidation. Insufficient accumulation of skeletal mass by the time young adulthood is reached appears to enhance the likelihood of fractures later in life, as age-related bone loss ensues. Although most of the emphasis on prevention of osteoporosis has focused on retarding bone loss, efforts need to be made to increase peak bone mass.

Three factors may be important in attaining peak bone mass—heredity, nutrition, and exercise. Of these, only the last two are subject to manipulation. There is relatively strong indirect evidence that an increase in dietary calcium can increase peak bone mass. Epidemiologic data from two Yugoslavian districts with an approximately twofold difference in calcium intake showed that persons in the district where calcium intake was lower had less cortical bone, and more hip fractures, than those in the other district. Differences were apparent in young adulthood, and the two groups did not diverge further as age progressed, suggesting that the major effect was on peak bone mass. Other indirect evidence includes the demonstration of increases in calcium consumption in populations previously accustomed to lower intakes, such as Japanese children following World War II, resulting in dramatic increases in skeletal stature. Based on their need for calcium to lay down new bone, adolescents should be receiving more calcium than adults, but as Chesnut pointed out, this often is not the case, and dairy products are replaced by diet cola beverages. There is even less information on the role of exercise, although studies evaluating this are currently under way.

The final panelist was Dr. S.J. Birge of Washington University in St. Louis, who discussed the role of exercise in preventing osteoporosis. The relationship between immobilization and bone loss is well known. Muscle mass and bone mass are directly related. Recently, compelling data have accumulated showing that an increase in physical activity delays bone loss and increases bone mass, although these are short-term effects. As expected, activities that increase the

loading stress to bone, such as aerobic dancing or jogging, are more effective than activities such as swimming, that do not. These short-term increases in bone density were of the same magnitude as those found after successful estrogen therapy. For example, in five recent studies, the rate of change in bone mass at various sites in postmenopausal women in an exercise program was about +3 percent per year, while it was about −3 percent per year in the sedentary control group.

Although these data are encouraging, three caveats should be mentioned. First, the rates of change in bone density, based on a relatively short period of observation (usually 1–2 years), may not be maintained for longer periods. Second, treatment and control groups have not always been randomly assigned and, therefore, other factors besides the effect of exercise may have been operating. Third, the amount of exercise required to achieve these rates requires rather intense weight-bearing exercises for 15–30 minutes a day several times a week, and this may not be appropriate for all women, some of whom may have other significant health problems, such as osteoarthritis of the knee or hip. Even so, the early results are extremely promising, and need to be extended and better quantified. Considering the other health benefits of increased exercise, however, including cardiovascular fitness, it is not too early to suggest that the entire adult population should increase its physical activity. Those at risk for osteoporosis should consider discussing with their physician the advisability of enrolling in a regular fitness training program.

References

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The Calcium Controversy: Finding a Middle Ground Between the Extremes

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Synopsis

Involutional bone loss, and the fracture syndromes that are designated "osteoporosis," are multifactorial phenomena. Gonadal hormone deficiency, inadequate exercise, and a multitude of lifestyle factors are involved in their pathogenesis. Calcium is important during growth, and probably up to about age 35, when peak bone mass is finally achieved. Recent controversy concerning the role of calcium in the middle-aged and elderly, arising out of population studies showing sometimes only weak calcium effects, can be resolved by recognizing the multifactorial character of involutional bone loss, and by careful attention to such details as national differences in habitual calcium intakes. Thus interpreted, metabolic, epidemiologic, and intervention studies are internally consistent, and indicate that inadequate calcium intake also makes an important contribution to involutional bone loss.

THE 1984 NATIONAL INSTITUTES OF HEALTH CONSENSUS DEVELOPMENT CONFERENCE proposed figures of 1,000 milligrams (mg) per day for estrogen-replete, perimenopausal women, and 1,500 mg per day for estrogen-deprived women remain the best estimates for recommended calcium intake. Such intakes are both safe and natural. While some people can adapt to intakes substantially below those levels, not all persons can, particularly many middle-aged women and the elderly of both sexes. Since we cannot