
Benefits of Calcium and Vitamin D: Building and Maintaining Healthy Bones

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There is no question that a generous intake of calcium plus vitamin D will help build optimum bone mass during childhood and adolescence and will also slow the rate of bone loss that naturally occurs with aging. These combined effects help protect against the development of osteoporosis, a disease caused by failure to build adequate bone mass or by progressive bone loss during aging. Osteoporosis by definition is a condition in which bone mass is sufficiently compromised to result in bone fragility. Most people do not get enough calcium or vitamin D from diet alone, and in many individuals osteoporosis is only recognized when a fracture occurs. Substantial research has shown supplements to be effective in maintaining or increasing bone density.

More than 99 percent of the body's calcium is found in the bones and teeth. While the bones have an obvious structural role, they also serve as the body's reservoir for calcium, since bone calcium can be mobilized and used for other purposes when needed. Calcium is also essential for muscle contraction and nerve transmission. Bone is not a static tissue, but is dynamic. It is constantly being resorbed and reformed, and the balance of these two activities determines whether bone is being added or lost in any particular person at any particular time. In growing children, the rate of bone formation is greater than the rate of bone resorption. In healthy young adults, the two processes are about balanced. During aging, the rate of formation falls behind the rate of resorption, and there is generally a net loss of bone.

Observations of an Expert: Dr. Robert P. Heaney

Dr. Robert P. Heaney of Creighton University, an internationally recognized expert on calcium and bone health, makes the process clear. He explains that bone is formed from structural materials such as calcium, phosphorus, and protein, all of which must be obtained from outside sources—that is, from dietary intake. A growing body must obtain these materials in adequate amounts from the diet. Even after growth has stopped, these substances must continue to be provided, because calcium and other components of bone are used for other functions and are lost from the body in considerable quantities every day. These losses must be offset by more intake. Otherwise, the body will treat the bones as a nutritional reserve and extract calcium from them to satisfy other needs. (Heaney 2000).

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“In the past 25 years there have been at least 139 published reports in English exploring the relationship between calcium intake and bone status,” according to Dr. Heaney. Almost all the randomized controlled trials in adults showed that increasing calcium intake reduced or stopped age-related bone loss, or reduced the rate of bone fractures, or both. All of the trials in children and adolescents showed that consuming supplemental calcium (from supplements or from dairy products) increased bone growth.

What conclusions can be drawn from these controlled studies? First, the current levels of calcium intake in children are not sufficient to fulfill their genetic potential for building bone mass. Also, current intakes among adults are not sufficient to protect the “bone capital” they have amassed during their lifetime. Dr. Heaney says “increasing calcium intake across the life span will enhance bone acquisition during growth, stabilize bone mass at maturity” and minimize bone loss during aging.

In addition to the controlled studies, there have been more than 86 observational studies on the association between calcium intake and bone mass. About three-fourths of these “support the hypothesis that increased calcium intake protects the skeleton.” Taken together, all the available studies firmly establish that high calcium intakes are important throughout life, that most Americans are not getting enough calcium, and that shortfalls of calcium intake have a major impact on bone health.

What about the role of calcium in treating people who have already suffered significant bone loss? “With the stimulus of growth long past, and with some of the bony scaffolding already destroyed by prior bone loss, supplemental calcium alone does not usually restore lost bone. However, high calcium intakes play a crucial and often little appreciated role as an adjuvant to formal therapeutic regimens. For example, high calcium intake augments the bone protective effect of standard estrogen replacement therapy in postmenopausal women, allowing a doubling or even tripling of the estrogen effect.”

Dr. Heaney says these synergistic effects should not be surprising. While hormones and other pharmaceutical treatments may stimulate bone building, “such agents do not themselves provide the raw materials of bone, which must come from the diet. Most of the therapeutic trials of bone-active agents have used, at most, very modest levels of calcium supplementation, and virtually none has used currently recommended maintenance intakes. It is likely, therefore, that we do not yet know the full therapeutic efficacy of the several agents now approved for treatment or prevention of osteoporosis, simply because none has been formally tested in the presence of full calcium and vitamin D sufficiency.” Dr. Heaney suggests that it would be prudent to include 1600 to 2400 mg per day of calcium as part of any treatment regimen directed at increasing bone mass.

Recommendations of the NIH Consensus Conferences on Osteoporosis

A Consensus Conference on Osteoporosis Prevention, Diagnosis, and Therapy convened by the National Institutes of Health in 2000 had this to say about calcium and osteoporosis: “Calcium is the nutrient most important for attaining peak bone mass and

for preventing and treating osteoporosis. Sufficient data exist to recommend specific dietary calcium intakes at various stages of life.” Yet only about 25 percent of teenage boys, around 10 percent of teenage girls, and approximately half of older adults actually consume the recommended amounts of calcium, according to the consensus conference report. The consensus conference also emphasized the role of vitamin D, which is required for optimal calcium absorption. (NIH Consensus Development Panel on Osteoporosis, 2000)

According to the NIH Consensus Development Panel, the probability of suffering an eventual hip fracture is 14 percent for a white woman at age 50 and about 5 percent for a white man at the same age. The risk for African Americans is much lower—6 percent for women and 3 percent for men at age 50. Nearly one-third of patients who have a hip fracture enter a nursing home within a year after the fracture, and one in five patients will die within a year after the fracture. The direct medical costs of treating fractures due to osteoporosis are in the range of \$10 billion to \$15 billion annually. (NIH Consensus Development Panel on Osteoporosis, 2000)

“Randomized clinical trials have demonstrated that adequate calcium intake from diet or supplements” increases bone mineral density, according to the NIH Consensus Development Panel. In other trials, combined supplementation with vitamin D and calcium has resulted in significant reductions in hip fracture and other fractures. The panel recommends that calcium and vitamin D also be given in conjunction with any drug therapy for osteoporosis. Other recommendations for prevention and treatment include getting plenty of weight-bearing exercise, avoiding falls, and using hormone replacement therapy after menopause. (NIH Consensus Development Panel on Osteoporosis, 2000)

Two earlier NIH Consensus Development Conferences on calcium and osteoporosis made similar findings. As early as 1984, the first Consensus Conference report concluded: “It seems likely that an increase in calcium intake to 1000 to 1500 mg/day beginning well before the menopause will reduce the incidence of osteoporosis in postmenopausal women. Increased calcium intake may prevent age-related bone loss in men as well . . . for those unable to take 1000 to 1500 mg of calcium by diet, supplementation with calcium tablets is recommended.” (NIH Consensus Conference on Osteoporosis 1984) Comparable conclusions were reached in the 1994 consensus conference. (NIH Consensus Conference on Optimal Calcium Intake 1994)

Recommendations of the Food and Nutrition Board

The Food and Nutrition Board of the Institute of Medicine issued new Dietary Reference Intakes for calcium and related nutrients in 1997. (Food and Nutrition Board 1997) The new “acceptable intakes” for calcium and vitamin D are shown below.

AGE GROUP	CALCIUM	VITAMIN D
Children 1-3	500 mg	5 µg (200 IU)
Children 4-8	800 mg	5 µg (200 IU)
Children 9-13	1300 mg	5 µg (200 IU)
Teens 14-18	1300 mg	5 µg (200 IU)
Adults 19-50	1000 mg	5 µg (200 IU)
Adults 51-70	1200 mg	10 µg (400 IU)
Adults over 70	1200 mg	15 µg (600 IU)

Compared to these levels, how much calcium do people actually consume? The Food and Nutrition Board report includes tables from the Continuing Survey of Food Intakes of Individuals (1994) that illustrate enormous shortfalls in calcium intake for most people, from their normal diets:

- 50 percent of children 4-8 years old consume less than 800 mg of calcium
- Over 75 percent of boys 9-13 and more than 50 percent of boys 14-18 get less than 1300 mg of calcium
- Almost 90 percent of girls 9-13 get less than 1300 mg of calcium
- About 95 percent of girls 14-18 consume less than 1300 mg of calcium
- Over 50 percent of men 19-50 get less than 1000 mg of calcium
- About 90 percent of women 19-50 fail to consume 1000 mg of calcium
- More than 90 percent of men over 50 fall short of getting 1200 mg of calcium
- Over 95 percent of women over 50 fail to consume 1200 mg of calcium

The intake levels established for calcium are based on the amounts needed for calcium balance and, in older populations, for maintenance of bone mineral density. The Food and Nutrition Board also established a Tolerable Upper Intake Level (UL) for calcium of 2500 mg per day for children or adults, while noting that “for the majority of the general population, intakes of calcium from food substantially above the UL are probably safe.” An upper limit of 50 µg (2000 IU) was set for vitamin D, for children and adults. For infants, the upper limit for vitamin D was set at half this amount, or 25 µg (1000 IU). (Food and Nutrition Board 1997)

National Study Shows Half of Women Over 50 Have Low Bone Mineral Density

The recent National Osteoporosis Risk Assessment study showed that almost half of women over 50 have undiagnosed low bone mineral density. In other words, they are at risk of bone fractures, without knowing it. The study measured the bone mineral density of more than 200,000 postmenopausal women 50 years of age or older with no previous diagnosis of osteoporosis. The women were recruited from more than 4000 medical practices in 34 states, and the average age at the time of recruitment was 65 years. Forty percent of the women had low bone mineral density (osteopenia but not osteoporosis) and an additional 7 percent had bone mineral density so low as to constitute osteoporosis. *During the year following recruitment into the study*, the women with osteopenia had twice the rate of bone fracture and the women with osteoporosis had four times the rate of bone fracture, compared to women with normal bone density. (Siris, et al, 2001)

At the time they were recruited into the study, 11 percent of the women (more than 22,000) had suffered a fracture since the age of 45. The authors say this finding is “disturbing,” adding: “These fractures are most likely to be a clinical consequence of osteoporosis, yet the diagnosis of osteoporosis had not been made, nor had appropriate treatment been implemented. This finding is consistent with several recently published reports, in which only 1 in 5 patients who had been seen with a minimal trauma fracture of the hip, wrist, spine, or shoulder had received treatment for osteoporosis within the next year; the likelihood of treatment decreased with increasing age at time of fracture. These results demonstrate an urgent need to educate health care professionals and patients that fracture in postmenopausal women implies osteoporosis unless proven otherwise.” (Siris 2001)

The National Osteoporosis Risk Assessment study “reaffirms the existence of a large population of women expected to live well into the 21st century who are at risk for future fracture. It also affirms the immediacy of risk...; the risk of fracture is not a decade or more in the future but, rather, exists at the time of the diagnosis.” (Siris 2001)

Recommendations of the National Osteoporosis Foundation

According to the nonprofit National Osteoporosis Foundation, about 10 million Americans already have osteoporosis, and another 18 million have low bone mass that puts them at risk for osteoporosis. **Every year, there are 1.5 million fractures due to osteoporosis.** These include 700,000 fractures of the vertebrae (back bone), 300,000 hip fractures, 250,000 wrist fractures, and 300,000 other types of fracture. The cost of treating these fractures in 1995 was \$13.8 billion, which amounts to \$38 million each and every day.

The four steps recommended by the National Osteoporosis Foundation are these:

- Get a balanced diet rich in calcium and vitamin D
- Get plenty of weight-bearing exercise

- Follow a healthy lifestyle with no smoking or excessive alcohol use
- Get tested for bone density and use medications when appropriate

Teens and adults need 1000 to 1300 mg of calcium per day, and surveys show that many women and young girls consume less than half this amount. A calcium supplement can help people make up the shortfall. Specific recommendations about choosing a calcium supplement are provided on the National Osteoporosis Foundation website. (National Osteoporosis Foundation, website www.nof.org)

Additional Key Scientific Studies

Researchers at the USDA Human Nutrition Research Center on Aging at Tufts University studied bone density in almost 400 men and women over 65 years of age. The subjects were given 500 mg of calcium plus 700 IU of vitamin D per day, or a placebo, for a period of three years. The group that received calcium and vitamin D experienced a significantly lower rate of bone loss and fewer nonvertebral fractures, compared to the placebo group. The researchers conclude that supplementation with calcium and vitamin D “may substantially reduce the risk of nonvertebral fractures among men and women 65 years of age or older . . .” (Dawson-Hughes 1997)

A four-year study of calcium supplementation conducted in New Zealand confirmed that the beneficial effects of calcium supplements are maintained over several years of regular use. In this study, 78 women who were at least three years beyond menopause were assigned to calcium (1 gram per day) or a placebo. The rate of total body bone loss was lower in the calcium group than in the placebo group. In addition, calcium supplementation was associated with a lower fracture rate. In the placebo group, seven women experienced nine fractures during the study, while there were only two fractures in the group getting 1 gram of calcium daily. (Reid 1995)

A study from France shows that calcium and vitamin D supplementation can not only decrease bone loss and reduce the incidence of fractures, but may slightly increase bone mass, even in the very old. For a period of 18 months, more than 3000 women over the age of 69 received 1.2 grams of calcium and 800 IU of vitamin D a day, or a placebo. In the supplemented group, there were 43 percent fewer hip fractures. Most surprisingly, bone density actually increased slightly in the group of elderly women who received the supplement. The authors concluded that “it may never be too late to prevent hip fracture.” (Chapuy 1992)

Researchers from the Helen Hayes Hospital and Columbia University in New York reviewed 31 studies on the effects of estrogen and seven studies on the effects of calcitonin. They found that giving calcium supplements along with estrogen or calcitonin substantially increased the positive effect on bone mass. The amount of calcium found to be beneficial was about 1200 mg per day. The researchers conclude: “An increasing calcium intake throughout the life span can benefit the skeleton, and, even in combination with [estrogen or calcitonin] treatment, calcium supplementation has a significant positive benefit to the skeleton.” (Nieves 1998)

Researchers in The Netherlands conducted a meta-analysis of 33 studies on calcium and bone mass in adults 18 to 50 years of age. The intervention trials indicate that a calcium supplement of about 1000 mg per day in premenopausal women “can prevent the loss of more than 1% of bone per year” at most bone sites. This could have a substantial impact on bone mass around the time of menopause. (Welten 1995)

What Does the Food and Drug Administration Say?

The Food and Drug Administration (FDA) has officially approved a health claim about calcium and osteoporosis. The health claim can be used on the labels of foods and dietary supplements that are good sources of calcium, and the labels can say that diets high in calcium may reduce the risk of osteoporosis. Health claims for foods and dietary supplements are permitted by FDA only after extensive review, based on a finding that the claim is supported by “significant scientific agreement.” The calcium health claim is one of only about a dozen approved by FDA since such claims were initially authorized in 1990 by the Nutrition Labeling and Education Act. (FDA 1993)

How Many Hip Fractures Could Be Prevented?

Even small protective effects could have a significant impact on individual health and quality of life while also reducing the nation’s high health care costs. One analysis concluded that the rate of hip fracture doubles about every five years as women age, beginning at about age 40. If protective measures could delay the process for only five years, this could potentially lower the rate of hip fracture in women by almost 50 percent. (Brody 1986)

A 1993 analysis by Dr. Robert P. Heaney estimated that adequate intakes of calcium and vitamin D in the elderly could reduce the rate of hip fracture by up to 20 percent, meaning 40,000 to 50,000 fewer hip fractures every year in the United States, for an average annual savings of \$1.5 to \$2 billion. Dr. Heaney recently commented that these estimates may be low, as some studies conducted since that time have demonstrated an even greater degree of risk reduction, as illustrated in the analysis by Bendich, cited below. (Heaney 1993)

In 1995, about 300,000 patients over the age of 50 were hospitalized with hip fractures in the United States. The estimated direct medical cost of caring for these patients was \$5.6 billion. Extrapolating from the protective effects observed in some clinical trials, researchers estimated that over 130,000 of these hip fractures could have been avoided, if people over the age of 50 habitually consumed about 1200 milligrams per day of supplemental calcium. The savings in direct health care cost, through avoiding these hip fractures, was calculated to be \$2.6 billion. (Bendich 1999)

What Would Be the Cost of Increasing Calcium Intake?

Increasing daily calcium intake by 1000 mg per day can be accomplished by using a dietary supplement, consuming foods fortified with calcium, or ingesting more dairy products. All three are considered to be roughly equivalent in terms of the bioavailability of the calcium they contain. (Food and Nutrition Board 1997) Thus, products can be compared directly on the basis of their calcium content.

Food sources of calcium tend to be more expensive than dietary supplement sources, but of course they also provide nutrients other than calcium. The cost of adding 1000 mg of calcium to the diet would be less than a quarter a day for most calcium supplements, less than a dollar a day if the calcium comes from lowfat milk or a calcium-fortified breakfast cereal, and about \$1.38 per day if the calcium comes from calcium-fortified orange juice. The table below shows the amount of each product that would need to be consumed to provide 1000 mg of additional calcium per day, and the cost for each product. (Costs are for products purchased from supermarkets in the Baltimore-Washington metropolitan area in 2002.)

PRODUCT	COST PER DAY	CALORIES
Dietary supplement, calcium carbonate, two tablets provide 1000 mg calcium, plus vitamin D	\$ 0.22	–
Dietary supplement, calcium carbonate, chewable, two chewable tablets provide 1000 mg calcium	0.18	20
Dietary supplement, soft calcium chews, two chews provide 1000 mg calcium, plus vitamin D.	0.28	40
Lowfat milk, 1 percent fat, 3.3 cups provide 1000 mg calcium	0.82	360
Calcium-fortified orange juice, 3 cups provide 1050 mg calcium	1.38	330
Breakfast cereal with added calcium, 2 cups provide 1000 mg calcium	0.90	330

Whether to change overall dietary habits to make room for additional high-calcium foods or simply to add a calcium supplement is a matter of personal choice. Adding a supplement appears to be the easiest and least costly option, but any of these alternatives would be an economical and sound investment in longterm health for any consumer.

Bottom Line

A generous intake of calcium, plus an appropriate amount of vitamin D, can significantly increase bone mass in growing children and young adults and can substantially decrease bone loss during aging. Most Americans do not get the amount of calcium recommended for optimal bone health, and the resulting fractures can be both costly and traumatic. It would make sense for most people to increase their calcium intake by 500 to 1000 mg per day, and one of the easiest and most economical ways to do this is to use a daily calcium supplement.

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