



BUILDING BETTER BONES WITH DAIRY FOODS THROUGHOUT THE LIFECYCLE

SUMMARY

Building and maintaining a healthy skeleton throughout life helps to reduce the risk of osteoporosis (i.e., weak, porous bones leading to bone fractures). This debilitating disease affects an estimated 44 million U.S. adults over the age of 50 and is responsible for 1.5 million fractures a year. According to the newly released Surgeon General's *Report on Bone Health and Osteoporosis*, prevention is key.

Multiple factors, genetic and environmental (e.g., nutrition, physical activity), influence bone health and risk of osteoporosis.

Among nutritional factors, consuming an adequate intake of calcium is important at all stages of life – in the early years to maximize genetically programmed peak bone mass and in later adulthood to maintain skeletal mass and minimize

age-related bone loss. In addition to calcium, other nutrients such as protein, phosphorus, magnesium, potassium, zinc, and vitamins A, D, and K support bone health.

Although most research has focused on single nutrients, evidence indicates that consuming naturally nutrient rich foods such as milk and other dairy products improves bone mineral status and helps to reduce the risk of osteoporosis.

Prevention of osteoporosis begins in childhood and adolescence because much of genetically determined peak bone mass is accrued during the first two decades of life. Studies in children and adolescents demonstrate that increasing consumption of dairy foods benefits bone health – or that low intake of dairy foods compromises bone health and may increase the risk of bone fractures during growth. Moreover, consuming an adequate intake of milk and

other dairy foods during childhood and adolescence may protect against fractures in later years. Establishing dietary habits that include milk early in life usually leads to lifetime milk consumption.

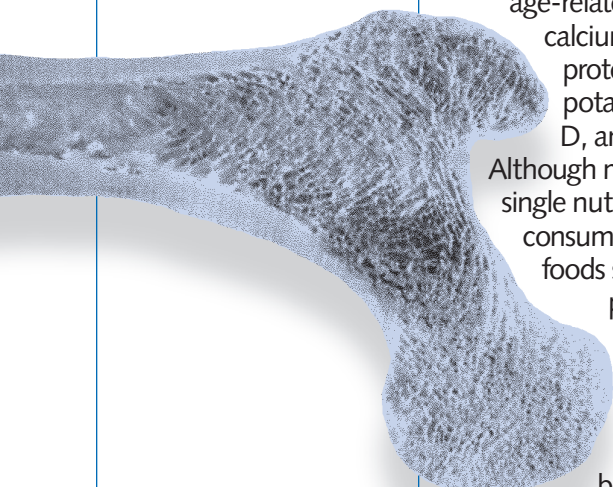
Investigations in adults demonstrate that consuming calcium-rich dairy foods such as milk, cheese, or yogurt reduces age-related bone loss and risk of osteoporotic fractures. These findings are not surprising given the high calcium content of dairy products, along with the presence of other nutrients needed for bone health in these foods. Recently, researchers conservatively estimated that consuming 3 to 4 servings of dairy foods/day could reduce osteoporosis-related fractures by at least 20%, resulting in healthcare cost savings of more than \$3.5 billion/year or \$14 billion over five years.

Milk and other dairy foods are the preferred source of calcium because of their high calcium content and the presence of other nutrients important for bone and overall health. Unfortunately, many Americans fail to consume the currently recommended 3 daily servings of milk, cheese, or yogurt.

In an effort to improve calcium intake and reduce the large toll that osteoporosis is inflicting on the nation, the dairy industry, with support from leading health professional organizations, has introduced a multi-year nutrition-based marketing and education campaign called "3-A-Day™ of Dairy for Stronger Bones" (www.3aday.org). The campaign's key message is to consume at least 3 servings a day of milk, cheese, or yogurt to build and maintain strong bones. The U.S. Surgeon General has launched a major campaign to increase Americans' awareness of osteoporosis and provide lifestyle strategies to promote bone health throughout life.



The Dairy Council Digest® is available on-line.
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INTRODUCTION

Osteoporosis, a skeletal disease characterized by reduced bone mass, structural deterioration, and excessive remodeling leading to increased bone fragility and susceptibility to fractures, affects an estimated 44 million U.S. adults over the age of 50 (1-3). Although 80% of those with osteoporosis are women, this disease also affects men and occurs in all races and ethnic groups (1,2). An estimated 1.5 million adults will suffer an osteoporosis-related fracture each year and up to 20% of those with hip fractures will die from injury-related complications within a year (1). Osteoporosis incurs direct care costs of up to \$18 billion a year (1). With the aging of the population, by 2020, half of Americans over age 50 will have or be at high risk for osteoporosis if preventive measures are not taken (1). The Surgeon General's first-ever *Report on Bone Health and Osteoporosis* emphasizes that it is essential to develop effective strategies throughout life to prevent and manage this bone disease (1).

Genetic and environmental (e.g., nutrition, physical activity) factors influence bone health and risk of osteoporosis (1-4). Nutrition is an important modifiable factor in the development and maintenance of bones, as well as the prevention and treatment of osteoporosis (1,5-7). Calcium and vitamin D have long been known to be beneficial for bone health (1,4-12). This is understandable considering that 99% of the body's calcium is stored in bones where it contributes to their strength and structure, and vitamin D enhances calcium absorption (8,11). Dairy foods such as milk are the major dietary source of calcium and vitamin D (1,8,13-15). High calcium intake, especially from dairy foods, along with adequate vitamin D status, has been demonstrated to maximize genetically programmed peak bone mass, which, for most of the skeleton, is reached by age 30 or earlier; to maintain skeletal mass in adulthood; and to slow age-related bone loss and/or reduce fracture risk in later adult years (9-12).

In an analysis of 139 scientific papers published between 1975 and 2000, 50 out of 52 controlled calcium intervention

studies showed a better bone balance, reduced bone loss, or decreased fracture risk at high calcium intakes (9). In an updated analysis of 180 papers, a positive relationship between calcium intake and bone health was supported in 68 out of 70 intervention studies (12). The majority (75% or more) of observational studies showed a positive association between calcium, dairy foods, and bone health (9,12), and all intervention studies that used dairy foods showed a beneficial effect on bone health (9).

Calcium is the specific nutrient most important for bone health (4,8). Low calcium intake is a chronic public health problem that begins after early childhood (1,4,16-20). The emergence of vitamin D insufficiency in almost every segment of the population has increased attention to its importance in bone health (21,22). Inadequate consumption of milk and other dairy products contributes to calcium shortages and low vitamin D status (4,19,21,23). Americans are consuming only an average of 1.5 servings each day from the Milk Group (24).

In addition to calcium and vitamin D, a wide variety of other nutrients affect bone status (5-7,25). These nutrients include protein, phosphorus, magnesium, potassium, zinc, and vitamins A, K, and C. For example, accumulating scientific evidence supports a beneficial role for protein in bone health, particularly when adequate calcium is consumed (26-28).

Although most research has focused on single nutrients, evidence also indicates that foods such as milk and other dairy products, and total dietary patterns affect bone health. Recently, researchers conservatively estimated that consuming 3 to 4 servings of dairy foods/day could reduce osteoporosis-related fractures by at least 20%, resulting in healthcare cost savings of more than \$3.5 billion/year or \$14 billion over five years (29). A dietary pattern such as the DASH (Dietary Approaches to Stop Hypertension) diet – a low fat, calcium-rich diet that emphasizes fruits, vegetables and dairy products – has been shown to significantly reduce bone turnover in adults, which immediately

Consuming 3 to 4 servings a day of dairy foods could reduce osteoporosis-related fractures by at least 20%, resulting in health-care cost savings of more than \$3.5 billion/year or \$14 billion over five years, according to a recent analysis.



reduces fragility and, if sustained, may improve bone mineral status and further reduce the risk of osteoporotic fractures (30,31). The researchers speculate that the skeletal benefit of the DASH diet is due to the presence of multiple nutrients packaged together in foods (30). For example, milk and other dairy foods are not only the major dietary source of calcium, but also provide a number of other nutrients such as protein, phosphorus, vitamin D, magnesium, potassium, and zinc (13-15) important for bone health (5-7,25).

This *Digest* reviews recent studies supporting a beneficial role for calcium-rich dairy foods in building and maintaining healthy bones throughout life. Also discussed is the importance of dairy foods as the preferred source of nutrients for healthy bones and efforts to improve Americans' dairy food intake and bone health.

THE ROLE OF DAIRY PRODUCTS IN BUILDING AND MAINTAINING HEALTHY BONES

Childhood and Adolescence.

Because much of genetically determined peak bone mass is accumulated during the first two decades of life, childhood and adolescence are critical times to optimize skeletal health (1,8,32,33). Maximal peak bone mineral content velocity occurs in boys at 14 years of age and in girls at 12.5 years (33). During the two years of peak skeletal growth, over 25% of adult bone mass is accumulated (33), and 90 to 95% of an adult's bone mineral is achieved by the end of adolescence (34).

Studies in children and adolescents demonstrate that increasing consumption of dairy foods has a beneficial effect on bone health or that low intake of dairy foods compromises bone health and increases the risk for bone fractures during growth. When Chinese children aged 9 to 10 years consumed milk powder equivalent to 1300mg of calcium for 18 months, bone mineral density of the hip and spine significantly increased (35). A study of children ages 3 to 10 years in New Zealand found that those with a history of



Studies demonstrate that increasing intake of milk and other dairy foods benefits bone health throughout life by helping to maximize genetically determined peak bone mass in the early years and reduce age-related bone loss and osteoporotic-related fractures.

chronically avoiding milk had a lower average dietary calcium intake, lower bone mineral density of the total skeleton and specific skeletal sites, and were shorter and heavier than children who drank milk (36). Also, the annual incidence of arm fractures in the milk avoiders was higher (3.5%) than the expected annual incidence (1%) (36).

A more recent investigation found that significantly more children aged 3 to 13 years who avoided milk for prolonged periods experienced bone fractures (especially forearm fractures) compared to a group of children born at the same time from the same city (37). Nearly one in three of the milk avoiders experienced a bone fracture before 8 years of age, most often from a minor trip or fall. Previously, these researchers showed that bone density was 3% to 5% lower at different skeletal sites in girls aged 3 to 15 years with a recent forearm fracture compared to those who had never broken a bone (38). Interestingly, a new report documents a significant increase in the number of distal forearm (wrist) fractures in U.S. children and adolescents over the past 30 years (39). Although the specific cause of this increase was not explored, the researchers suggest that the decline in milk consumption and dramatic increase in soft drink intake in recent decades is likely a contributing factor (39).

A study found that the calcium intake of girls from age 5 to 9 predicted bone mineral status at 9 years of age and that girls who met the calcium recommendation consumed on average nearly twice as much milk as those who did not meet the calcium recommendation (40). Further, girls who met the calcium recommendation were served milk more often and had mothers who drank milk more frequently than did girls with low calcium intakes.

Several investigations support a beneficial effect of dairy foods on bone health during adolescence as well. A British study of 80 adolescent girls found that bone mineral density and bone mineral content increased in those who consumed an additional daily pint of milk for 18 months (41). Findings from recent studies of adolescent girls in China demonstrate that increasing milk intake increases bone mineral content and

bone mineral density, particularly when milk is fortified with vitamin D (42,43). In a 12-week randomized clinical trial in the U.S., whole body bone mineral density was significantly higher in adolescent boys (13 to 17 years of age) who drank 3 servings/day of milk while participating in a strength training program compared with boys who drank juice (44). The researchers suggest that this beneficial effect on bone was most likely due to the additional calcium and/or vitamin D consumed by the milk drinkers (44).

Further support for a positive effect of calcium and dairy products on bone health in adolescents is provided by findings from a study of two groups of adolescent girls (15 to 18 years) (45). One group was part of a randomized double-blind, placebo-controlled clinical trial with calcium supplements, and the other group was part of an observational study in which calcium was provided by dairy products. Both calcium and dairy products improved bone mass accrual, leading to a higher peak bone mass (45). While calcium influenced volumetric bone density, dairy products had an additional impact on bone growth and bone expansion, perhaps due to the calcium and protein content of dairy products (45).

Retrospective studies indicate that milk intake during childhood and adolescence is associated with greater bone mass and protection against fractures in later years (46,47). According to data from more than 3,200 women, reported frequency of milk intake during childhood and adolescence was positively associated with bone mineral content and bone mineral density of the hip in those aged 20 and older (46). Among women 50 years and older, those with low milk intake during childhood had a 2-fold greater risk of osteoporotic fractures than women with high milk intake during childhood (46). In an investigation of young women aged 18 to 31 years, higher reported milk intakes during childhood and adolescence were associated with higher total bone mineral content in young adulthood (47). This finding indicates that early establishment

of dietary habits that include milk may contribute to similar milk-drinking habits in later years (47). Health professional organizations such as the American Academy of Pediatrics (23) and the American Dietetic Association (48), as well as the U.S. Surgeon General (1) recognize the importance of calcium and calcium-rich foods such as milk, cheese, and yogurt for children's bone health.

Adulthood. Numerous studies indicate that increasing calcium intake, either alone or in combination with other nutrients in dairy products, helps to reduce bone loss and risk of fractures in adulthood (4,7-12,25,49-53). The effectiveness of calcium varies according to skeletal site, menopausal age, and usual calcium intake (8). For example, the effect of calcium on bone health is relatively small in early menopause (i.e., the first 5 to 8 years of menopause) when bone loss is accelerated due to estrogen deficiency (8). However, calcium is an important adjunct to estrogen and other medications to reduce bone loss (54-57).

Consuming milk and other calcium-rich dairy foods has a positive effect on bone health in adults (58-63). In a cross-sectional study of healthy Norwegian women aged 19 to 35 years, lack of milk intake was associated with low forearm bone mineral density, whereas milk consumption was a significant source of calcium, which was associated with higher bone mineral density of the wrist and forearm (58). In a two-year randomized controlled trial of postmenopausal Chinese women aged 55 to 65 years in Malaysia, intake of high calcium skimmed milk significantly reduced bone loss at clinically important lumbar spine and hip sites (59). Compared to the control group, which continued to consume their usual diet, the milk treatment group had significantly higher intakes of dietary calcium and improved vitamin D status at 24 months (59). The researchers note that the findings of this study support those of a previous investigation demonstrating that high calcium milk reduces age-related bone loss in postmenopausal Chinese women (60).

According to the first-ever Surgeon General's Report on Bone Health and Osteoporosis, it is never too late to take steps, such as increasing calcium intake and physical activity, to help prevent osteoporosis.



Increasing adults' dietary calcium in the form of foods (e.g., yogurt, milk) has been demonstrated to decrease bone resorption (breakdown), the first step in reducing fragility (31), as well as in maintaining bone density (61,62). Consuming a yogurt snack three times a day significantly improved postmenopausal women's intake of calcium and other nutrients (e.g., riboflavin, vitamin B₁₂, potassium, protein) and decreased their rate of bone resorption, as indicated by urinary excretion of N-telopeptide, according to a randomized controlled clinical trial (61). In another study of healthy older adults with habitually low intakes of dairy foods, those who consumed 3 servings of fat free or lowfat milk as part of their daily diet for 12 weeks experienced a significant decrease in bone resorption compared to those who maintained their usual diets (62). According to a recent cross-sectional study, higher consumption of dairy foods was associated with increased hip bone mineral density in older men (63).

Dairy foods' beneficial effect on bone health in older adults is consistent with findings from studies of dairy food nutrients and bone health (27,51-53,63-66). A review of the calcium needs of adults over 65 years of age concludes that increasing daily calcium intake (e.g., from 1300 to 1700 mg/day) will reduce osteoporotic fracture risk by 30% to 50% (53). According to a meta-analysis of 25 randomized controlled trials in postmenopausal women, vitamin D significantly reduced spine fractures and showed a trend toward reduced incidence of non-spine fractures (64). Interventions that have used both calcium and vitamin D demonstrate a reduced risk of falls (65) and bone fractures (51) in older adults. Protein is another nutrient in dairy foods that favorably affects bone health in older adults, particularly when adequate calcium is consumed (27,66).

Bone building and maintenance throughout the lifecycle require a continuous supply of calcium, protein, phosphorus, magnesium, potassium, zinc, and vitamins A, D, and K – nutrients found in dairy products.



CONCLUSION

Foods naturally rich in calcium, such as dairy products, are the preferred source of calcium (4,8,9,23,53,67-70). Consuming at least the recommended number of servings of dairy foods each day increases intake of not only calcium and other nutrients essential for building and maintaining healthy bones, but it also improves the overall nutritional quality of the diet (15,68,71). As reviewed in a recent *Digest* (71), there is increasing support among government and health professional organizations to recommend 3 to 4 servings of dairy foods a day to meet calcium needs.

Calcium-fortified foods and/or calcium supplements can help close the calcium gap for individuals unable to consume sufficient dietary calcium. However, their use does not solve the underlying problem of inadequate dietary patterns of food selection, which are responsible for Americans' generally low calcium intake (68,72). The bioavailability of calcium in some calcium-fortified beverages may be less than expected (69,73). On the other hand, calcium fortification of widely consumed foods may lead to excess calcium intake for some groups (74). Increasing calcium intake from calcium supplements in the absence of an otherwise healthy diet may lead to nutrient imbalances (e.g., phosphorus deficiency), which could potentially harm bones (75).

To build and maintain healthy bones throughout life and prevent osteoporosis, health professionals recommend a nutritionally balanced diet with adequate calcium and vitamin D, regular weight-bearing exercise, and a healthy lifestyle with no smoking and limited alcohol intake (1-4,9,23,69,70).

Efforts such as the "3-A-Day™ of Dairy for Stronger Bones" campaign (www.3aday.org) and the Surgeon General's report (1) aim to increase awareness of the importance of achieving and maintaining healthy bones throughout life and strategies to prevent and treat osteoporosis. **D**

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www.3aday.org

- Wanted: Stronger Bones, a patient education tool (click on Health Professionals, under Education Materials)

- 3-A-Day™ Dairy Tracker and Mealtime Makeover

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- Preventing Osteoporosis: Starting In Childhood. *Dairy Council Digest* 70(5), 1999.
- 3-A-Day™ of Dairy For Stronger Bones. *Dairy Council Digest* 74(1), 2003.
- Dietary Protein & Bone Health: New Perspectives. *Dairy Council Digest* 74(5), 2003.

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