



BUILDING STRONG BONES: STARTING IN THE EARLY YEARS

SUMMARY

Prevention of osteoporosis, a debilitating disease characterized by low bone mass and increased risk of fractures, is a public health priority. Although this disease typically affects older adults, its prevention begins in childhood and adolescence by optimizing genetically determined peak bone mass reached sometime between late adolescence and the early 20s.

Bone mass is determined by genetics and environmental factors such as diet and exercise. Although many nutrients influence bone health, most attention has focused on calcium. Dietary calcium recommendations are 800 mg/day for children aged 4 through 8 years and 1,300 mg/day for children and adolescents 9 through 18 years of age. Unfortunately, most U.S. children older than 8 years fail to consume recommended intakes of calcium. Low intake of milk and other dairy foods (e.g., cheese, yogurt), the major dietary source of calcium, contributes in large part to low calcium intake. Dairy foods also contain other bone-building nutrients including vitamin D (if fortified), phosphorus, protein, potassium, magnesium, and zinc.

Several factors influence children's and adolescents' consumption of dairy foods, such as replacement of milk by soft drinks, fruit juices, and/or fruit drinks. Parents and other family members, through role modeling or by consuming and serving dairy

foods themselves, can positively impact children's and adolescents' dairy and calcium intakes. For this reason, the American Academy of Pediatrics (AAP) encourages adequate calcium intake by all family members.

Numerous studies demonstrate that consuming an adequate intake of dairy foods and/or calcium during childhood and particularly adolescence is important for optimizing genetically determined peak bone mass. This in turn may reduce the risk of osteoporosis in later adult years. Childhood and adolescence is a critical period for establishing healthful dietary practices and lifestyle behaviors that, if maintained, can support skeletal health.

The 2005 Dietary Guidelines for Americans, recognizing the important role of dairy foods in improving overall diet quality, nutrient adequacy, and children's and adolescents' bone health, recommends 3 cups of low-fat or fat-free milk or equivalent milk products a day for children 9 years of age and older (2 cups a day or equivalent for children 2 to 8 years).

In a recent report on bone health, the AAP outlines several strategies to optimize bone health and calcium intake of children and adolescents. These include consuming 3 servings of calcium-rich dairy foods (e.g., low-fat milk, flavored milk, cheese, or yogurt) a day for children 4 to 8 years of age and 4 servings a day for children and adolescents 9 to 18 years of age as part of a well-rounded diet including fruits and vegetables, and participating in regular physical activity, especially weight-bearing exercise. The AAP encourages physicians to regularly assess children's and adolescents' calcium intakes and suggests that families at risk of inadequate calcium intake consult a registered dietitian for dietary advice. **D**



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INTRODUCTION

Osteoporosis, a skeletal disease characterized by low bone mass and increased susceptibility to fractures, affects 44 million U.S. adults over the age of 50 (1). This chronic disease results in considerable morbidity and mortality and incurs direct healthcare costs reaching \$18 billion a year (1). Even though this bone disease strikes late in life, its prevention begins in childhood and adolescence (1). Achieving genetically-determined peak bone mass, reached sometime during late adolescence and the early 20s, reduces the risk of osteoporosis later in life (1). In addition to genetics, environmental factors such as diet and physical activity influence bone health (1).

With respect to diet, dairy foods such as milk, cheese, and yogurt contribute a number of nutrients including calcium, vitamin D (if fortified), phosphorus, protein, potassium, magnesium, and zinc, which are important for bone health (1,2).

Most attention has focused on calcium because of its critical role in bone structure and its generally low dietary intake (1). Approximately 99% of total body calcium is found in the skeleton. The amount of bone accumulated during growth is related to the amount of calcium consumed (1). Because of the increased rate of bone growth during childhood and adolescence, calcium needs are high during these years (3). Unfortunately, many youth, especially those older than 8 years of age, fail to meet their needs for calcium, primarily because of their low intake of dairy foods, the major dietary source of calcium (4,5).

Studies in children and adolescents demonstrate that increasing intake of dairy foods or calcium increases peak bone mass and possibly reduces risk of fractures during childhood (1,3,6). The 2005 Dietary Guidelines for Americans (7) acknowledges the important role of milk and other dairy foods such as yogurt and cheese for children's bone health. The Guidelines report recommends 2 cups of low-fat or fat-free milk or equivalent milk products a day for children 2 to 8 years and 3 cups of milk a day or its equivalent for children 9 years of age and older (7). The American Academy of Pediatrics (AAP),



The proportion of children consuming an adequate intake of calcium is lowest between the ages of 12 and 19 years when accumulation of bone mineral peaks and the requirement for calcium is highest.

recognizing the wide gap between typical calcium intakes and dietary calcium recommendations, issued a report on optimizing children's and adolescents' bone health and calcium intakes (8). This report recommends 3 servings of milk, cheese, or yogurt a day for children aged 4 to 8 years and 4 servings a day for children and adolescents 9 to 18 years of age, as well as other calcium-rich foods (8).

This *Digest* reviews children's calcium needs, intake, and factors influencing their dairy food and calcium intake; scientific findings supporting a beneficial role for dairy foods and calcium in bone health; and recommendations to optimize children's and adolescents' bone health.

CHILDREN'S AND ADOLESCENTS' CALCIUM NEEDS AND INTAKES

For children aged 4 to 8 years, 800 mg of calcium/day is recommended, whereas for children and adolescents aged 9 through 18 years, 1,300 mg of calcium/day is recommended (3). This higher calcium recommendation coincides with peak calcium accretion rates in bone which occur at an average age of 12.5 years for girls and 14 years for boys (8,9).

For most children over 8 years of age and adolescents in the U.S., calcium intakes are below daily recommended levels (4,8,10,11). According to data from the National Health and Nutrition Examination Survey (NHANES) 2001-2002, only 6% of girls and 28% of boys aged 9 to 13 years and only 9% of girls and 31% of boys aged 14 to 18 years have calcium intakes greater than recommended (4). Not only does dietary calcium intake decline with age, but at all ages females' calcium intake is much lower than that of males (4,10).

In addition to calcium, bone health depends on an adequate vitamin D status, which increases calcium absorption (1,3,7,8). The current dietary recommendation for vitamin D for children and adolescents is 200 I.U. per day (3,12). Vitamin D status is influenced by exposure of the skin to sunlight and diet. Because few foods naturally contain vitamin D, virtually all milk in the U.S. is voluntarily fortified with vitamin D at a level of 400 I.U. per quart (3).

Two cups of vitamin D-fortified milk provides 200 I.U. of vitamin D, the amount recommended for children and adolescents. Some cheeses and yogurts as well as some breads, cereals and juices are also fortified with vitamin D. In recent years, there have been several reports of low vitamin D status among U.S. adolescents, especially those who are not regularly exposed to sunlight and/or do not consume at least 2 cups/day of vitamin-D fortified milk (12-15).

Inadequate consumption of milk and other dairy foods contributes to low dietary intake of calcium (and vitamin D) (1,2,10,16). Dairy foods are the major source of dietary calcium, providing 72% of the calcium in the U.S. food supply (17). On average, adolescent girls aged 12 to 19 years are consuming only 1.7 servings/day from the Milk Group, while similar aged boys are consuming 2.4 servings/day (5). Without including adequate amounts of dairy foods (i.e., at least 3 servings/day) in the diet, it is improbable that daily recommended dietary intakes of calcium will be met (1,2).

Many factors influence children's and adolescents' dairy intake, each of which needs to be considered in efforts to promote adequate calcium intake (8,10). A preoccupation with being thin or the misperception that all dairy foods are fattening can limit intake of these foods (8,10). The 2005 Dietary Guidelines for Americans (7) advises adults and children to not avoid milk and milk products because of concerns about weight gain. Also, the AAP report points out that "children, adolescents, and parents may not be aware that low-fat milk contains at least as much calcium as whole milk" (8).

Replacement of milk intake by soft drinks and fruit juices and/or fruit drinks may contribute to adolescents' low calcium intakes (8-10,18-20). This concern was expressed in the AAP's policy statements restricting soft drinks in schools (19) and limiting juice intake in children (20). Lactose maldigestion, which is more common in children of African, American Indian, and Asian descent than in white children, may lead to restriction of dairy and calcium intake (8,10). However, many children with lactose maldigestion can consume dairy products without discomfort by drinking smaller amounts of milk (e.g., 1 cup)

Because of the family's influence on children's and adolescents' diets, family members are encouraged to serve as role models by consuming and serving milk and other dairy foods themselves.



especially with meals, eating aged cheeses (e.g., Cheddar, Swiss), or consuming yogurt with live active cultures (7,21,22). Lactose-free and low lactose milks are other options to encourage children to meet the recommended 3 servings/day of dairy foods. In a new report on lactose intolerance, the AAP recommends that children and adolescents with lactose intolerance consume dairy foods, as suggested above, in order to obtain enough calcium, vitamin D, protein, and other nutrients essential for bone health and growth (21).

Parents, through role modeling, expectations and attitudes, can influence their children's dairy and calcium intake (8,23-25). Researchers have found that mothers who drink milk more often tend to have young daughters who drink milk frequently and consume fewer soft drinks (23). A study of 192 girls followed from ages 5 to 9 and their mothers found that, at age 9, the girls who consumed recommended dietary intakes of calcium drank twice the amount of milk, had slightly higher bone mineral density, and had mothers who drank and served milk more frequently than girls with low calcium intakes (24). Some recent studies show that breakfast consumption improves children's and adolescents' calcium intake (26,27).

IMPROVING CHILDREN'S BONE HEALTH: WHAT STUDIES SHOW

Consuming an adequate intake of dairy foods and/or calcium during childhood and particularly adolescence is important for optimizing bone health, which may help reduce the risk of fractures in childhood and adolescence and osteoporosis in later adult years (1,3,6,28-32). In young children, increasing calcium intake has been shown to increase bone mineral density (1,3,6,24, 28-35). In a recent six-year prospective study of 151 Caucasian girls followed from age 5 to 11, higher calcium intakes (provided mainly from dairy products) at ages 7 and 9 years were positively associated with total body bone mineral content at age 11 (34). In another longitudinal study of young children aged 2 to 8 years, multiple nutrients (energy, calcium, phosphorus, protein, magnesium, and zinc) showed a positive

and significant correlation with bone mineral content (35). This finding led the researchers to suggest that children should consume a variety of nutrient-rich foods to protect their bone health (35).

Meeting calcium needs during adolescence is particularly important for bone health given that 40% of adult bone mass is accrued during the few years of peak skeletal growth (1,8). The benefits of increased calcium on adolescents' bone health are demonstrated in a number of studies (1,3,6,28-32,36-38). A one-year double-blind, placebo-controlled calcium intervention study (1,000 mg calcium carbonate/day) in 100 post-menarcheal girls with habitual low calcium intakes (<800 mg/day) found that calcium supplementation (1,000 mg/day) enhanced bone mineral acquisition, especially in girls who were two years past the onset of menarche (37).

Because milk and other dairy products are the major dietary source of calcium and provide other bone-building nutrients, several studies have examined their effect on bone health in children and adolescents (30,38-45). Researchers found that bone mineral content and bone mineral density were significantly increased in a study of 80 girls aged 12 years who consumed additional calcium (i.e., 1,125 mg/day compared to baseline calcium intake of 746 mg/day) in the form of whole or low-fat milk (i.e., two cups) for 18 months (39). A clinical study in 28 boys between 13 and 17 years of age found that increasing milk intake (3 servings of 1% fluid milk/day) favorably affected bone mineral responses to resistance training (40). A recent two-year placebo-controlled intervention trial in Finland found that consuming cheese to increase calcium intake was more beneficial for bone mass accrual in girls aged 10 to 12 years than a similar amount of calcium from calcium supplements (41). Other investigations in U.S. and Asian children and adolescents indicate that intake of dairy products has a positive influence on bone mineral density (42-45). A retrospective study showed that women aged 20 to 49 years who consumed more milk during



To optimize bone health, the American Academy of Pediatrics recommends 3 servings of dairy foods (e.g., low-fat milk, flavored milk, cheese, or yogurt) a day for children 4 to 8 years of age and 4 servings a day for children and adolescents 9 to 18 years, along with weight-bearing exercise.

childhood had higher bone mineral content than those whose intake of milk intake during childhood was low (46).

Overall, controlled trials of calcium or dairy intake have reported positive short-term effects on bone measures during growth, particularly when habitual calcium intake is low (28,29,32). But whether or not there is a long-term benefit in attaining and maintaining maximum peak bone mass after the dairy food or calcium intervention is stopped has yet to be conclusively established (1,8,28,47). Several follow-up investigations indicate that the effects of dairy food or calcium intake on gain in bone mineral density are maintained (i.e., from 1 to 7.5 years, depending on the study) after the intervention is discontinued (33,48-52), whereas in other studies no sustained effect has been observed (53,54). Factors such as the timing of pubertal maturation, source of calcium (food or supplement), and habitual calcium intake may influence the lasting response to calcium supplementation. Because it is unknown whether a short-term increase in calcium results in a long-term benefit on bone health, it is important that dietary practices that promote adequate calcium intake be established in childhood and maintained throughout life (8).

Emerging evidence indicates that fractures in childhood and adolescence are related to low bone mass or skeletal fragility, which in turn is influenced by diet and physical activity (30,55-58). A recent meta-analysis of eight case-control studies found a positive association between low bone density and fractures in children (55). New Zealand children and adolescents aged 5 to 19 years with repeated forearm fractures had lower bone mineral content and weighed more, two factors that increase fracture risk, compared to fracture-free children of the same age and gender (56). Previous research by these investigators showed an increased incidence of fractures in children who avoided milk (58).

In addition to adequate calcium intake, weight-bearing exercise (e.g., running, jumping) is important to optimize bone

health during growth (1,8). The AAP states that “there is evidence that childhood and adolescence may represent an important period for achieving long-lasting skeletal benefits from regular exercise” (8). Some studies demonstrate that increasing calcium or dairy intake enhances the positive effects of high physical activity on bone mineral status during growth (59-63). However, additional research is necessary to determine the combined effects of calcium and exercise on bone health during childhood and adolescence (8,64).

STRATEGIES TO OPTIMIZE BONE HEALTH DURING GROWTH

The importance of calcium and calcium-rich foods such as milk, cheese, and yogurt for children's and adolescents' bone health is recognized by health professional and government organizations (1,7,8,65,66). The 2005 Dietary Guidelines for Americans (7) states that consuming milk products is associated with “overall diet quality and adequacy of intake of many nutrients” and “is especially important for children and adolescents who are building their peak bone mass and developing lifelong habits.” In a position statement on dietary guidance for healthy children, the American Dietetic Association (65) recognizes that children's “failure to meet calcium requirements in combination with a sedentary lifestyle in childhood can impede the achievement of maximal skeletal growth and bone mineralization, thereby increasing the diet-related risk of developing osteoporosis later in life.” In its report on optimizing children's bone health, the AAP (8) states that “drinking three 8-oz glasses of milk per day (or the equivalent. . .) will achieve the recommended adequate intake of calcium in children 4 to 8 years of age, and four 8-to-10-oz of milk (or the equivalent) will provide the adequate calcium intake for adolescents.” The report identifies yogurt and cheese as good sources of calcium and adds that “flavored milks, cheeses, and yogurts containing reduced fat or no fat and

modest amounts of sweeteners (both caloric and non-caloric) are generally recommended” (8). The National Medical Association consensus panel recommends 3 daily servings of low-fat milk, cheese, and/or yogurt a day for children and 4 servings a day for adolescents (66).

Milk and other dairy foods are identified as the preferred dietary source of calcium (1,3,7,8). Not only are milk and other dairy products calcium-dense foods providing about 300 mg calcium/serving, but these foods also contain other nutrients important for bone health such as vitamin D (if fortified), phosphorus, protein, potassium, magnesium, and zinc (1,2). In fact, milk contains three nutrients (i.e., calcium, potassium, and magnesium) which the 2005 Dietary Guidelines (7) identifies as being low in the diets of children. Nondairy calcium-containing foods (e.g., some green leafy vegetables, beans) and calcium-fortified foods are other sources, although the bioavailability of calcium in some of these foods (e.g., spinach) is low (8,67). Calcium supplements are another source, but the AAP (8) cautions that “these products do not offer the benefit of other associated nutrients, and compliance may be a problem.” For individuals who rely on calcium-fortified foods or nondairy foods low in vitamin D, another source of vitamin D is needed to provide an adequate intake of 200 IU of vitamin D/day (8).

Childhood and adolescence is a critical period for establishing healthful dietary practices and lifestyle behaviors that, if maintained, can support skeletal health throughout life.

In addition to consuming a nutritionally balanced diet including low-fat dairy products, fruits, and vegetables, children and adolescents should be physically active and participate in weight-bearing activities to optimize their bone health (1,8). Also, parents should be role models of healthy behaviors by serving milk at mealtimes and choosing milk as a beverage when eating out (8). The AAP recommends that physicians periodically assess children's and adolescents' calcium intake beginning at 2 to 3 years of age and have discussions with parents and families regarding their dietary habits to ensure that they are meeting daily calcium requirements (8). Information regarding the calcium content of

various foods should be given to patients and their families at risk of low calcium intakes. A registered dietitian may be consulted for a more thorough dietary assessment and to offer recommendations to increase calcium intake (8). Resources such as the Calcium Assessment Questionnaire, a new tool developed by the AAP and National Dairy Council (www.nationaldairyCouncil.org), can help families determine if they are getting the calcium they need from their diets. **D**

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- www.nationaldairyCouncil.org (under Health Professional Resources) Calcium Counseling Resource National Dairy Council. Dairy's role in children's health and wellness. *Dairy Council Digest* 76(5), 2005. National Dairy Council. Building better bones with dairy foods throughout the lifecycle. *Dairy Council Digest* 75(6), 2004.
- www.nationaldairyCouncil.org (under Nutrition & Product Information) Thinking About Calcium? Find It in Food First Wanted: Stronger Bones Bone Health Advertorial
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