

# Optimizing Bone Health in Children and Adolescents: Implications for Current and Future Health

## Background

Although bone health has always been an issue for our population of children and adolescents, over the past decade concern has been elevated to unprecedented levels.<sup>1</sup> With life expectancy on the rise in the United States, osteopenia and osteoporosis have become increasing health concerns among the older population. Both of these terms refer to lower-than-normal bone mineral density, which can result in debilitating bone fractures and falls as one ages. Optimizing bone health in childhood and adolescence results in stronger, denser bones in adulthood and reduces the chance of developing these diseases later in life.

There are consequences of lower bone mineral density realized early in life as well. Children and adolescents today are more likely to break a bone than their parents were. Studies from the United States, Sweden and Japan have shown that fracture incidences have risen steadily in the past four decades. Age-adjusted incidence rates in the United States are 32 percent higher in boys and 56 percent higher in girls in the time span between 1969-1971 and 1991-2001.<sup>2</sup> There are many hypotheses for this increase in fracture risk. Experts believe that reduced dairy consumption and thus lower calcium and vitamin D intakes—important nutrients in optimizing bone mass deposition—may play a role in the escalating fracture incidence. Lower levels of physical activity—particularly weight-bearing types—among our young population and higher incidence of overweight and obesity have also been linked to greater fracture risk.

Thus, it is more important than ever to ensure that children and adolescents optimize their peak bone mass (PBM) to avoid fractures early in life and to prevent or delay development of osteopenia and osteoporosis later in life.

## Calcium intake is irrefutably linked to bone health

Bone health is influenced by many factors, including genetics, physical activity and nutrition. Calcium deserves special attention, as it is the largest component of bone minerals and is deficient in many diets. It is well-known that consuming an adequate intake of calcium during childhood and adolescence is critical for the development of PBM, which helps to reduce the risk of fractures and osteoporosis in later years. Because an adult cannot compensate for

inadequate PBM deposited in adolescence, prevention of osteoporosis starts in childhood. Optimizing calcium intake for bone health is particularly important during adolescence, as peak calcium-accretion rate occurs on average at 12.5 years in girls and 14.0 years in boys.<sup>3</sup> In addition, during the 3- to 4-year period of rapid bone mass deposition during adolescence, 40 percent of total adult bone mass is accumulated.<sup>4</sup>

A multitude of studies has shown that increasing dairy or calcium intakes during childhood and adolescence enhances bone health at various skeletal sites,<sup>5</sup> particularly in those populations with low calcium intakes.<sup>6</sup> Because it is difficult to accurately assess dietary calcium, intervention studies are prioritized over observational studies. In a 3-year clinical trial of 22 pairs of twins, average age 7 years, the twin who consumed 1,600 milligrams of calcium a day deposited 3 to 5 percent more bone mass than his or her counterpart, whose intake was only 900 milligrams per day.<sup>7</sup> A clinical trial in 8-year-old girls showed that increasing calcium intake from 900 to 1,750 milligrams per day for one year increased bone mineral density in the arms, hips and spine,<sup>8</sup> with effects greatest in those with low baseline calcium intakes. Other clinical trials in pre-teens and teens have similarly found that increasing calcium intake, either from dairy food sources or from supplements, increases bone density.<sup>9-12</sup>

The source of calcium in optimizing bone health seems to be important. Various observational and epidemiological studies indicate that consuming milk and other dairy foods during childhood and adolescence is a primary determinant of bone health.<sup>13-17</sup> Clinical studies whereby milk or other dairy products were added to subjects' diets also show increases in bone mineral density at various sites,<sup>18</sup> as well as improved nutrient intakes.<sup>18,19</sup> In addition, children who avoid milk are known to have suboptimal bone mass and are at higher risk of fractures.<sup>20-23</sup> Goulding et al. found bone density to be 3 to 5 percent lower in girls aged 3 to 15 years who had forearm fractures, compared to those who had never broken a bone.<sup>24</sup> In another study, fracture incidence in children who avoid milk was 160 percent higher than expected from average fracture rates in the population.<sup>22</sup>

Increasing calcium and/or dairy intakes in children and adolescents is well accepted as a means of increasing bone mineralization, at least over a short period of time. Whether these benefits persist after intervention has stopped, however, is not clear, with some studies indicating that the effects are maintained for up to 7-1/2 years<sup>25-27</sup> and others finding no sustained effect.<sup>28,29</sup> To ensure long-term benefits of optimal bone health, therefore, it is important to sustain adequate calcium intakes not just during the childhood and adolescent years but into adulthood as well.

Some research, on the other hand, does not confirm this relationship between calcium intake and bone health. Calcium supplementation trials do not always produce the expected results in bone mineral density to the extent needed to reduce risk of fractures,<sup>30,31</sup> or gains may have been observed but not maintained over time.<sup>11</sup> There are various explanations for these discrepancies between studies. Subjects' baseline calcium intakes may be high enough that additional calcium, either in the form of diet or supplements, does not lend any additional benefit to bone health and/or fracture rates. Methods available for estimating habitual calcium intakes are not ideal and

invariably introduce some error. Assessing long-term calcium intakes can pose challenges as researchers are dependent upon children's or caregivers' memories of past calcium intakes. Still, the overwhelming preponderance of research supports a strong connection between calcium intake and bone health.

### Bone health is associated with fracture risk

Although fracture incidence is significantly higher today than it was a generation ago, the reasons for this are not completely understood. Research suggests that risk factors may involve inadequate bone mass, early age of first fracture, adverse symptoms to and avoidance of cow's milk, low dietary calcium intakes, lack of physical activity and being overweight.<sup>32</sup>

A recent meta-analysis in 10 case-control studies suggests an association between low bone density and fractures in children.<sup>33</sup> Observational data also show dietary calcium intake predicts fracture risk; high calcium intakes are associated with a protective effect against fractures in adolescent boys and girls,<sup>34</sup> and children with low calcium intakes have a fracture rate 2.7 times greater than birth-cohort controls.<sup>35</sup> A recent case-control study found that girls with a history of a

milk-free diet due to allergy had a 4-1/2 times greater risk of fracture; this association was not observed in boys.<sup>36</sup> Another study found that of 50 children aged 3 to 13 years, those who avoided milk reported higher incidence of fractures and the majority of those fractures were associated with only slight trauma.<sup>22</sup>

Research also shows that overweight children experience more fractures than normal-weight children,<sup>37</sup> and children who have a fracture at an early age have a higher rate of repeat fractures.<sup>32</sup> A case-control study in boys aged 3 to 19 years found that high adiposity and low bone mineral content were associated with increased risk of forearm fractures.<sup>38</sup> Another study found that high body weight contributes to fracture risk in children and adolescents who fracture their forearms repeatedly.<sup>32</sup> Body weight may contribute to fracture risk by placing extra burden on bones during falls. Lack of physical activity—common in overweight children—may also play a role in fracture risk, as physical activity is associated with stronger bones.

### Calcium sources and equivalents to 1 cup of milk

Food	Serving Size	Calcium Content (mg/serving)	Amount needed to equal 1 cup of milk*
Milk	1 cup	290	1
Beans, Pinto	3 ounces	45	8.1
Bok Choy	1/2 cup	79	2.3
Broccoli	1/2 cup	35	4.5
Cheese, cheddar	1.5 ounces	303	1
Mustard greens	1/2 cup	212	1.1
Kale	1/2 cup	61	3.2
Orange juice, calcium-fortified	1 cup	300	0.88
Soy beverage, calcium-fortified	1 cup	300	1.3
Spinach	1/2 cup	115	16.3
Sweet potatoes	1/2 cup	44	9.8
Yogurt	1 cup	300	1
Tofu, calcium-set	1/2 cup	258	1.2

\*Takes into account average calcium content of food listed and bioavailability. Adapted from reference 45.

## Calcium intakes versus recommendations: Still a big gap

The majority of children and teens do not consume nearly enough dietary calcium on a daily basis. It is estimated that nine out of 10 girls and seven out of 10 boys aged 12 to 19 years do not consume adequate calcium.<sup>39</sup>

Children aged 9 to 19 years need 1,300 milligrams of calcium, the highest of any age group, to optimize the calcium deposited in their bones during this time of rapid growth. Various government agencies and health organizations encourage consumption of dairy products as the primary sources of dietary calcium. The 2005 Dietary Guidelines for Americans recognize the importance of dairy in the diet in meeting calcium needs and recommend that everyone 9 years and older consume 3 cups of low-fat dairy foods as part of a healthful diet.<sup>40</sup> Similarly, in the U.S. Surgeon General's Report on Bone Health and Osteoporosis,<sup>1</sup> three daily servings of low-fat milk are recommended to build and maintain strong bones. In its report on optimizing bone health and calcium intakes of infants, children and adolescents, the American Academy of Pediatrics recommends three 8-ounce glasses of milk a day, or the equivalent, for children 4 to 8 years of age, and four glasses for adolescents.<sup>4</sup> Finally, the National Medical Association recommends that the American public—African Americans in particular—consume three to four servings of low-fat milk, cheese or yogurt a day to help reduce the risk of nutrient-related diseases such as osteoporosis.<sup>41</sup>

Unfortunately, American adolescents do not come close to these recommendations. Currently, it is estimated that teenage boys consume only about 2.4 servings of dairy per day, while teenage girls consume about 1.7 servings a day.<sup>42</sup> Other foods—dark green, leafy vegetables such as kale and bok choy—are also dietary sources of calcium and can help to make up the difference, but it takes many more servings of these to get the same amount of calcium as that in 3 to 4 cups of milk (see Table).

## Other nutrients involved in bone health

Other nutrients besides calcium are critical to bone health. Vitamin D, protein, phosphorus, magnesium, potassium, vitamin B12 and zinc are all needed in bone deposition. Consuming a well-balanced diet

composed of a variety of foods, including dairy products and other calcium-rich foods, fruits and vegetables, grains and meat or beans on a daily basis is the best way to ensure an adequate intake of all these important bone-building nutrients.

## The role of the practicing health professional

Pediatricians and other health professionals who work with children and adolescents are in an ideal position to monitor and assess calcium status, identifying marginal or deficient intakes that can lead to fractures and future issues with osteopenia and osteoporosis. In evaluating current and future bone health in young clients, consider the following:

- Experts agree that it is best to consume adequate calcium from nutrient-rich food sources rather than supplements whenever possible. Children need two to three servings of dairy a day to meet their needs for optimal bone health; adolescents need three to four servings. A serving is equivalent to 1 cup of milk or yogurt and 1-1/2 ounces of cheese. All milks, regardless of fat level or added flavorings, contain about 300 milligrams of calcium per cup.
- Calcium intake should be assessed at least three times during childhood and adolescence during routine check-ups: at 2 or 3 years of age, during preadolescence (8 to 9 years), and during early adolescence.<sup>4</sup> Education materials geared for these specific ages can facilitate client education.
- Because dairy foods account for 72 percent of the calcium in the United States food supply,<sup>43</sup> query parents and caregivers of young children as to their usual intake of dairy products. Adolescents and teens can be asked directly about their habitual diets. Remember that dairy foods contain a “package” of bone-building nutrients such as vitamin D, magnesium, phosphorus and protein.
- Offering cheese and yogurt at snack time is an ideal way to consume extra dairy servings, and generally appeal to even the most selective of children and adolescents. Other calcium-rich foods, such as beans, nuts and dark green, leafy vegetables, can round out daily calcium intake needed for optimal bone health.

- In situations in which it is not possible for children and adolescents to consume the needed levels of dairy foods, products fortified with calcium are another option. Juices, breakfast cereals, bars and other calcium-fortified foods are plentiful on the market shelves. If these are consumed in place of dairy foods, however, ensure that vitamin D intake is also adequate.
- Assess physical-activity levels in children and adolescents as well, emphasizing weight-bearing activities like running, jumping or walking that enhance bone health.

- To identify children with bone mass deficits and to monitor changes in bones due to chronic disease or therapies, clients' bone mineral density and content can be checked against age-, race- and sex-specific reference curves.<sup>44</sup>
- Follow up at each visit to re-evaluate diet and activity levels, as these can change rapidly and whimsically in this age group. Emphasize the importance of consistently eating a calcium-rich diet and obtaining adequate levels of physical activity on a daily basis.

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