AMERICAN ACADEMY OF PEDIATRICS

Committee on Nutrition

Calcium Requirements of Infants, Children, and Adolescents

ABSTRACT. This statement is intended to provide pediatric caregivers with advice about the nutritional needs of calcium of infants, children, and adolescents. It will review the physiology of calcium metabolism and provide a review of the data about the relationship between calcium intake and bone growth and metabolism. In particular, it will focus on the large number of recent studies that have identified a relationship between childhood calcium intake and bone mineralization and the potential relationship of these data to fractures in adolescents and the development of osteoporosis in adulthood. The specific needs of children and adolescents with eating disorders are not considered.

Approximately 99% of total body calcium is found in the skeleton, with only small amounts found in the plasma and extravascular fluid. Serum calcium exists in 3 fractions: ionized calcium (approximately 50%), protein-bound calcium (approximately 40%), and a small amount of calcium that is complexed, primarily to citrate and phosphate ions. Serum calcium is maintained at a constant level by the actions of several hormones, most notably parathyroid hormone and calcitonin. Calcium absorption is by the passive vitamin D-independent route or by the active vitamin D-dependent route.[1]

Understanding calcium needs for different age groups requires a consideration of the variable physiologic requirements for calcium during development. For example, during the first month of life, the regulatory mechanisms that maintain serum calcium levels may not be entirely adequate in some otherwise healthy infants, and symptomatic hypocalcemia can occur. However, in general, hypocalcemia is uncommon in healthy children and adolescents, and the primary need for dietary calcium is to enhance bone mineral deposition.

Calcium requirements also are affected substantially by genetic variability and other dietary constituents. The interactions of these factors make identification of a single unique number for the calcium "requirement" for all children impossible.[2–4] However, several recent dietary guidelines have considered the data about calcium requirements and recommended calcium intake levels that are calculated to benefit most children (Table 1).[2,3]

In addition to calcium intake, exercise is an important aspect of achieving maximal peak bone mass. There is evidence that childhood and adolescence may represent an important period for achieving long-lasting skeletal benefits from regular exercise.[5] For example, Welten et al[6] showed in a large Dutch cohort of children that regular weight-bearing activity had a greater influence on peak bone mass than dietary calcium.

IDENTIFICATION OF MINERAL REQUIREMENTS DURING CHILDHOOD

Overview

It is recognized that a very low calcium intake can contribute to the development of rickets in infants and children, especially those consuming very restrictive diets (eg, a macrobiotic diet).[7] There are no reliable data on the lowest calcium intake needed to prevent rickets or on the relationship among ethnicity, vitamin D status, physical activity, and diet in the causation of rickets in children fed low-calcium diets.[8,9]

Recent data support the possibility that a low bone mass may be a contributing factor to some fractures in children. A relationship between the adolescent growth spurt and the risk of fractures has been shown.[10,11] Goulding et al[12] reported lower bone mass at multiple sites in a group of 100 girls aged 3 to 15 years with distal forearm fractures compared with age-matched girls. For girls aged 11 to 15 years in the study by Goulding et al[12] a lower calcium intake was reported for those with fractures compared with the control subjects. Wyshak and Frisch[13] similarly reported that high calcium intakes seem to exert a protective effect against fractures in adolescent boys and girls. They also reported a positive relationship between cola beverage intake and bone fracture. Whether this is attributable to a potential effect of excessive phosphorus in the colas impairing bone mineral status or to the lack of calcium intake related to the substitution of colas for dairy products is uncertain. However, a direct harmful effect of a high phosphorus intake affecting the bone mineral status is unlikely in older children and adults.[2] Further data on the relationship between calcium intake and fractures are needed before the magnitude of increased fracture risk at different calcium intake levels can be assessed. However, it is reasonable to conclude that low calcium intakes may be an important risk factor for fractures in adolescents. This risk may be an issue that adolescents can more readily relate to than a long-term risk of osteoporosis.

Maintaining adequate calcium intake during childhood is necessary for the development of a maximal peak bone mass. Increasing peak bone mass may be

The recommendations in this statement do not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

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TABLE 1. Dietary Calcium Intake (mg/d) Recommendations in the United States[2,3]*

Age	1997 NAS[3]	1994 NIH[2]
0 to 6 mo†	210	400
6 mo to 1 y†	270	600
1 through 3 y	500	800
4 through 8 y	800	800 (4–5 y)
		800–1200 (6–8 y)
9 through 18 y	1300	800–1200 (9–10 y)
		1200–1500 (11–18 y)

* Recommended intakes were provided in different forms by each source cited. The Food and Nutrition Board of the National Academy of Sciences (NAS) released Recommended Dietary Allowances until 1997. In 1997, it chose to use the term *adequate intake* for the recommendations for calcium intake but indicated that these values were to be used as Recommended Dietary Allowances. The NIH Consensus Conference did not specify a specific term but indicated that these values were the "optimal" intake levels. Dietary recommendations by the NAS are set to meet the needs of 95% of the identified population of healthy subjects. The NAS guideline should be the primary guideline utilized.
† For infant values, the 1994 NIH Consensus Conference indicated values for formula-fed infants, whereas the 1997 NAS report used the infant fed human milk as the standard.

an important way to reduce the risk of osteoporosis in later adulthood.[2,14] This is a more difficult end point to identify than the development of rickets or fractures. Therefore, surrogate markers of mineral status are used to assess the consequences of differing levels of calcium intake. The primary surrogates used are optimization of calcium balance or achievement of greater bone mass in children with increased calcium intake.[3,14,15]

In children with chronic illnesses, fractures may occur during childhood secondary to mineral deficiency associated with the disease process or the effects of therapeutic interventions (ie, corticosteroids) on calcium metabolism.[16] However, minimal data generally are not available on the risks and benefits of increasing calcium intake in children with chronic illnesses above current dietary recommendations. Supplementation of vitamin D along with calcium may be necessary for a maximal response.[17]

Methods

Multiple approaches are used to assess mineral requirements in children. They include the following: 1) measurement of calcium balance in persons with various levels of calcium intake; 2) measurement of bone mineral content, by dual-energy radiograph absorptiometry or other techniques, in groups of children before and after calcium supplementation; and 3) epidemiologic studies relating bone mass or fracture risk in adults with childhood calcium intake.

The calcium balance technique consists of measuring the effects of any given calcium intake on the net retention of calcium by the body. This approach has been the most commonly used to estimate requirement for minerals. Its usefulness is based on the rationale that virtually all retained calcium must be used, especially by children, to enhance bone mineralization. It therefore is reasonable to expect that the dietary intake that leads to the greatest level of calcium retention is the intake that will lead to the greatest benefit for promoting skeletal mineralization and decreasing the ultimate risk of osteoporosis.[18,19]

The substantial limitations involved in obtaining and interpreting data about calcium balance are well known. These include substantial technical problems with measuring calcium excretion and the difficulty obtaining dietary intake control in children. Both of these are necessary for adequate balance studies. These problems have been partly overcome by the development of stable isotopic methods to assess calcium absorption and excretion.[20] Nevertheless, more data are needed to establish the "optimal" level of calcium retention at different ages and the effects of development on calcium balance.[6]

A major advance in the field during the last 25 years has been the development and improvement of methods to measure total body and regional bone mineral content by using various bone density techniques. Currently, the technique used in many studies is dual-energy radiograph absorptiometry. This technique can rapidly measure the bone mineral content and bone mineral density of the entire skeleton or of regional sites with a virtually negligible level of radiation exposure. Furthermore, recent enhancements in the precision of the technique have made it particularly suitable for assessing the effects of calcium supplementation on bone mass in children of all ages.[21]

Several groups have directly assessed the effects of calcium supplementation on bone mass by using dual-energy radiograph absorptiometry or similar techniques.[22–25] These studies, however, also have limitations. First, most supplementation studies done in children involved relatively short-term supplementation of 1 to 2 years. This period may be inadequate to fully assess the long-term benefits of calcium supplements on bone mineral density. The second is that these studies generally have been done using only 1 level of supplementation, which frequently has been given in pill form. This limited dosing approach makes it difficult to identify an optimal intake level or determine the relative benefits of dietary calcium versus supplements as a method of increasing calcium intake in children.

Several investigators have performed population-based epidemiologic studies relating childhood or adult bone mass or fracture risk to calcium intake in childhood. Although many of these studies are limited by their retrospective design, they have generally shown a positive association between calcium intake in childhood and childhood and adult bone mass. Not all studies have shown a benefit, however, and further data about this relationship are needed.[3,26–28]

RECOMMENDATIONS BY AGE GROUP

Overview

The specific requirements for calcium intake by infants, children, and adolescents have been extensively reviewed by 2 panels in North America since 1994.[2,3] A summary of their recommendations is shown in Table 1.

Infants

The optimal primary nutritional source during the first year of life is human milk. No available evidence shows that exceeding the amount of calcium retained by the exclusively breastfed term infant during the first 6 months of life or the amount retained by the human milk–fed infant supplemented with solid foods during the second 6 months of life is beneficial to achieving long-term increases in bone mineralization. Available data demonstrate that the bioavailability of calcium from human milk is greater than that from infant formulas or cow's milk, although this comparison has not generally been made at comparable intake concentrations, ie, such as found in human milk.[29] Nevertheless, it has been deemed prudent to increase the concentration of calcium in all infant formulas relative to human milk to ensure at least comparable levels of calcium retention. Relatively greater calcium concentrations are found in specialized formulas, such as soy formulas and casein hydrolysates, to account for the potential lower bioavailability of the calcium from these formulas relative to cow's milk-based formula. Specific concentration requirements cannot be set readily, but all formulas marketed should have demonstrated a net calcium retention at least comparable to that of human milk. Research data are not available to justify the use of very high levels of calcium in infant formula for full-term infants.

Premature infants have higher calcium requirements than full-term infants while in the nursery. These may be met by using human milk fortified with additional minerals or with specially designed formulas for premature infants.[30] After hospitalization, there may be benefits to providing formula-fed premature infants formulas with higher calcium concentrations than those of routine cow's milk–based formulas.[31] The optimal concentrations and length of time needed for such formulas are unknown.

Children

Few data are available about the calcium requirements of children before puberty. Calcium retention is relatively low in toddlers and slowly increases as puberty approaches. Most available data indicate that calcium intake levels of about 800 mg/d are associated with adequate bone mineral accumulation in prepubertal children. The benefits of greater levels of intake in this age group have been studied inadequately.[20,32] One study found a benefit of calcium supplements to children as young as 6 years of age.[16] However, further supporting data are needed for this finding. Perhaps of most importance in this age group is the development of eating patterns that will be associated with adequate calcium intake later in life.

Preadolescents and Adolescents

The majority of research in children about calcium requirements has been directed toward 9- to 18-year-olds. The efficiency of calcium absorption is increased during puberty, and the majority of bone formation occurs during this period.[15,20,21,32,33] Data from balance studies suggest that for most healthy children in this age range, the maximal net calcium balance (plateau) is achieved with intakes between 1200 and 1500 mg/d. That is, at intake levels above this, almost all of the additional calcium is excreted and not used. At intakes below that level, the skeleton may not receive as much calcium as it can use, and peak bone mass may not be achieved.[2,3,9,15,18–20] Virtually all the data used to establish this intake level are from white children; minimal data are available for other ethnic groups. The exact level that is best for a given person depends on other nutrients in the diet, genetics, exercise, and other factors.

Several controlled trials have found an increase in the bone mineral content in children in this age group who have received calcium supplementation.[22–25] However, the available data suggest that if calcium is supplemented only for relatively short periods (ie, 1 to 2 years), there may not be long-term benefits to establishing and maintaining a maximum peak bone mass.[34,35] This emphasizes the importance of diet in achieving adequate calcium intake and in establishing dietary patterns consistent with a calcium intake near recommended levels throughout childhood and adolescence. Unfortunately, long-term studies evaluating the consequences of maintaining currently recommended calcium intakes beginning in childhood or early adolescence are not available. Most available epidemiologic data, recently reviewed by the National Academy of Sciences and the National Institutes of Health, support the view that maintaining such a diet will increase peak bone mass and lower the incidence of fractures.[2,3]

Recent data obtained in African American adolescents suggest a link between lower diastolic blood pressure and increased calcium intake. Further studies are necessary to evaluate this relationship in children of multiple ethnicities and age groups.[36]

ACHIEVING RECOMMENDED INTAKES

The gap between the recommended calcium intakes and the typical intakes of children, especially those 9 to 18 years of age, is substantial (Table 1). Mean intakes in this age group are between approximately 700 and 1000 mg/d, with values at the higher side of this range occurring in males.[3] Preoccupation with being thin is common in this age group, especially among females, as is the misconception that all dairy foods are fattening. Many children and adolescents are unaware that low-fat milk contains at least as much calcium as whole milk.

Knowledge of dietary calcium sources is a first step toward increasing the intake of calcium-rich foods. Table 2 gives typical amounts of calcium for some common food sources. The largest source of dietary calcium for most persons is milk and other dairy products.[37] Other sources of calcium are, however, important, especially for achieving calcium intakes of 1200 to 1500 mg/d. Most vegetables contain calcium, although at low density. Therefore, relatively large servings are needed to equal the total intake achieved with typical servings of dairy products. The bioavailability of calcium from vegetables

TABLE 2. Approximate Calcium Contents of 1 Serving of Some Common Foods*

Food	Serving Size		Calcium Content
Milk†	1 cup	240 mL	300 mg
White beans	½ cup	110 g	113 mg
Broccoli cooked	½ cup	71 g	35 mg
Broccoli raw	1 cup	71 g	35 mg
Cheddar cheese	1.5 oz	42 g	300 mg
Low-fat yogurt	8 oz	240 g	300–415 mg
Spinach cooked‡	½ cup	90 g	120 mg
Spinach raw‡	1½ cup	90 g	120 mg
Calcium-fortified orange juice	1 cup	240 mL	300 mg
Orange	1 medium	1 medium	50 mg
Sardines or salmon with bones	20 sardines	240 g	50 mg
Sweet potatoes	½ cup mashed	160	44

* Adapted from Raper et al,[37] Weaver,[38,39] and Weaver and Plawecki.[40]
† Low-fat milk has comparable or greater calcium levels than whole milk.
‡ The calcium from spinach is essentially nonbioavailable.

is generally high. An exception is spinach, which is high in oxalate, making the calcium virtually nonbioavailable. Some high-phytate foods, such as whole bran cereals, also may have poorly bioavailable calcium.[38–40]

Several products have been introduced that are fortified with calcium. These products, most notably orange juice, are fortified to achieve a calcium concentration similar to that of milk. Limited studies of the bioavailability of the calcium in these products suggest that it is at least comparable to that of milk.[41] It is likely that more such products will soon become available. Breakfast foods also are frequently fortified with minerals, including calcium. Calcium intakes on food labels are indicated as a percentage of the "daily value" in each serving. This daily value is currently set as 1000 mg/d. Therefore, it is important to instruct families about reading and interpreting food labels.

Several alternatives exist for children with lactose intolerance. Lactose intolerance is more common in African American, Mexican Americans, and Asian Pacific Islanders than in whites.[42] Many children with lactose intolerance can drink small amounts of milk without discomfort. Other alternatives include the use of other dairy products, such as solid cheeses and yogurt, that may be better tolerated than milk. Lactose-free and low-lactose milks are available. Increasing the intake of nondairy products, such as vegetables, may be helpful, as may the use of calcium-supplemented foods.

For children and adolescents who cannot or will not consume adequate amounts of calcium from any dietary sources, the use of mineral supplements should be considered. Although supplements vary in their bioavailability, they may have bioavailability comparable to or greater than that of dairy products.[43] Decisions about their use must be made on an individual basis, keeping in mind the usual dietary habits of the person, any individual risk factors for osteoporosis, and the likelihood that the use of the supplement will be maintained.

CONCLUSION

Recent studies and dietary recommendations have emphasized the importance of adequate calcium nutriture in children, especially those undergoing the rapid growth and bone mineralization associated with pubertal development. The current dietary intake of calcium by children and adolescents is well below the recommended optimal levels. The available data support recent recommendations for calcium intakes of 1200 to 1500 mg/d beginning during the preteen years and continuing throughout adolescence as recommended by the National Institutes of Health Consensus Conference[2] and the National Academy of Sciences.[3] Currently, evidence is inadequate to alter the dietary recommendations for children with chronic illnesses or those taking medications, such as corticosteroids, that alter bone metabolism. However, an effort should be made to achieve at least the recommended intake levels. The provision of adequate vitamin D also may be important for children with chronic illnesses.

RECOMMENDATIONS

1. Pediatricians should actively support the goal of achieving calcium intakes in children and adolescents comparable to those in recently recommended guidelines.[2,3] The prevention of future osteoporosis, as well as the possibility of a decreased risk of childhood and adolescent fractures, should be discussed as potential benefits to achieving these goals. Currently, relatively few children and adolescents achieve dietary calcium intake goals.
2. To emphasize the importance of calcium nutriture, pediatricians should consider including the following questions about dietary calcium intake.
   - What do you drink, either white or chocolate milk, with your meals?
   - Do you drink milk with meals, snacks, or cereal or any other time during the day?
   - Do you eat cheese, yogurt, or other dairy products such as cottage cheese?
   - Do you drink calcium-fortified juices or eat any calcium-fortified foods?
   - Do you eat any of the following: broccoli, tofu, oranges, or legumes (dried beans and peas)?
   - Do you take any mineral or vitamin supplements?
3. For children and adolescents whose calcium intake seems deficient, specific information about the sources of dietary calcium should be pro-

vided. Adolescents may need to be reminded that low-fat dairy products, including skim milk and low-fat yogurts, are good sources of calcium that are not high in fat.

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REFERENCES

1. Broadus AE. Physiological functions of calcium, magnesium, and phosphorus and mineral ion balance. In: Favus MJ, ed. *Primer on the Metabolic Bone Diseases and Disorders of Mineral Metabolism.* 2nd ed. New York, NY: Raven Press; 1993:41–46
2. National Institutes of Health Consensus Conference. NIH consensus development panel on optimal calcium intake. *JAMA.* 1994;272: 1942–1948
3. Institute of Medicine, Food and Nutrition Board. *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride.* Washington, DC: National Academy Press; 1997
4. Committee on Dietary Allowances, Food and Nutrition Board, National Research Council. *Recommended Dietary Allowances.* 10th ed. Washington, DC: National Academy Press; 1989
5. Slemenda CW, Miller JZ, Hui SL, Reister TK, Johnston CC Jr. Role of physical activity in the development of skeletal mass in children. *J Bone Miner Res.* 1991;6:1227–1233
6. Welten DC, Kemper HC, Post GB, et al. Weight-bearing activity during youth is a more important factor for peak bone mass than calcium intake. *J Bone Miner Res.* 1994;9:1089–1096
7. Dagnelie PC, Vergote F, van Staveren WA, van den Berg H, Dingjan PG, Hautvast JG. High prevalence of rickets in infants on macrobiotic diets. *Am J Clin Nutr.* 1990;51:202–208
8. Legius E, Proesmans W, Eggermont E, Vandamme-Lombaerts R, Bouillon R, Smet M. Rickets due to dietary calcium deficiency. *Eur J Pediatr.* 1989;148:784–785
9. Pettifor JM, Ross P, Wang J, Moodley G, Couper-Smith J. Rickets in children of rural origin in South Africa: is low dietary calcium a factor? *J Pediatr.* 1978;92:320–324
10. Bailey DA, Wedge JH, McCulloch RG, Martin AD, Bernhardson SC. Epidemiology of fractures of the distal end of the radius in children as associated with growth. *J Bone Joint Surg Am.* 1989;71:1225–1231
11. Parfitt AM. The two faces of growth: benefits and risks to bone integrity. *Osteoporos Int.* 1994;4:382–398
12. Goulding A, Cannan R, Williams SM, Gold EJ, Taylor RW, Lewis-Barned NJ. Bone mineral density in girls with forearm fractures. *J Bone Miner Res.* 1998;13:143–148
13. Wyshak G, Frisch RE. Carbonated beverages, dietary calcium, the dietary calcium/phosphorus ratio, and bone fractures in girls and boys. *J Adolesc Health.* 1994;15:210–215
14. Miller GD, Weaver CM. Required versus optimal intakes: a look at calcium. *J Nutr.* 1994;124:1404S–1405S
15. Matkovic V, Ilich JZ. Calcium requirements for growth: are current recommendations adequate? *Nutr Rev.* 1993;51:171–180
16. Abrams SA. Studies of calcium metabolism in children with chronic illnesses. In: Wastney ME, Siva Subramanian KN, eds. *Kinetic Models of Trace Element and Mineral Metabolism During Development.* Boca Raton, FL: CRC Press; 1995:159–170
17. Warady BD, Lindsley CB, Robinson FG, Lukert BP. Effects of nutritional supplementation on bone mineral status of children with rheumatic diseases receiving corticosteroid therapy. *J Rheumatol.* 1994;21:530–535
18. Jackman LA, Millane SS, Martin BR, et al. Calcium retention in relation to calcium intake and postmenarcheal age in adolescent females. *Am J Clin Nutr.* 1997;66:327–333
19. Matkovic V, Heaney RP. Calcium balance during human growth: evidence for threshold behavior. *Am J Clin Nutr.* 1992;55:992–996
20. Abrams SA, Stuff JE. Calcium metabolism in girls: current dietary intakes lead to low rates of calcium absorption and retention during puberty. *Am J Clin Nutr.* 1994;60:739–743
21. Ellis KJ, Abrams SA, Wong WW. Body composition in a young multiethnic female population. *Am J Clin Nutr.* 1997;65:724–731
22. Lloyd T, Andon MB, Rollings N, et al. Calcium supplementation and bone mineral density in adolescent girls. *JAMA.* 1993;270:841–844
23. Johnston CC Jr, Miller JZ, Slemenda CW, et al. Calcium supplementation and increases in bone mineral density in children. *N Engl J Med.* 1992;327:82–87
24. Lloyd T, Martel JK, Rollings N, et al. The effect of calcium supplementation and tanner stage on bone density, content and area in teenage women. *Osteoporos Int.* 1996;:6:276–283
25. Lee WT, Leung SS, Wang SH, et al. Double-blind, controlled calcium supplementation and bone mineral accretion in children accustomed to a low-calcium diet. *Am J Clin Nutr.* 1994;60:744–750
26. Lee WT, Leung SF, Lui SS, Lau J. Relationship between long-term calcium intake and bone mineral content of children aged from birth to 5 years. *Br J Nutr.* 1993;70:235–248
27. Matkovic V, Kostial K, Simonovic I, Buzina R, Brodarec A, Nordin BE. Bone status and fracture rates in two regions of Yugoslavia. *Am J Clin Nutr.* 1979;32:540–549
28. Sandler RB, Slemenda CW, LaPorte RE, et al. Postmenopausal bone density and milk consumption in childhood and adolescence. *Am J Clin Nutr.* 1985;42:270–274
29. Fomon SJ, Nelson SE. Calcium, phosphorus, magnesium, and sulfur. In: Fomon SJ. *Nutrition of Normal Infants.* St Louis, MO: Mosby–Year Book, Inc; 1993:192–218
30. Schanler RJ, Abrams SA. Postnatal attainment of intrauterine macromineral accretion rates in low birth weight infants fed fortified human milk? *J Pediatr.* 1995;126:441–447
31. Bishop NJ, King FJ, Lucas A. Increased bone mineral content of preterm infants fed with a nutrient enriched formula after discharge from hospital. *Arch Dis Child.* 1993;68:573–578
32. Abrams SA, Grusak MA, Stuff J, O'Brien KO. Calcium and magnesium balance in 9–14-y-old children. *Am J Clin Nutr.* 1997;66:1172–1177
33. Matkovic V, Jelic T, Wardlaw GM, et al. Timing of peak bone mass in Caucasian females and its implication for the prevention of osteoporosis: inference from a cross-sectional model. *J Clin Invest.* 1994; 93:799–808
34. Slemenda CW, Peacock M, Hui S, Zhou L, Johnston CC. Reduced rates of skeletal remodeling are associated with increased bone mineral density during the development of peak skeletal mass. *J Bone Miner Res.* 1997;12:676–682
35. Lee WT, Leung SS, Leung DM, Cheng JC. A follow-up study on the effects of calcium-supplement withdrawal and puberty on bone acquisition of children. *Am J Clin Nutr.* 1996;64:71–77
36. Dwyer JH, Dwyer KM, Scribner RA, et al. Dietary calcium, calcium supplementation, and blood pressure in African American adolescents. *Am J Clin Nutr.* 1998;68:648–655
37. Raper NR, Zissa C, Rourke J. *Nutrient Content of the US. Food Supply,*

1909–1988. Washington, DC: US Dept of Agriculture; 1992. Home Economics Research Report No. 50
38. Weaver CM. Calcium bioavailability and its relation to osteoporosis. *Proc Soc Exp Biol Med*. 1992;200:157–160
39. Weaver CM, Hauney RP, Prouly WR. Choices for achieving adequate dietary calcium with a vegetarian diet. *Am J Clin Nutr*. 1999;70(suppl): 534S–538S
40. Weaver CM, Plawecki KL. Dietary calcium: adequacy of a vegetarian diet. *Am J Clin Nutr*. 1994;59(suppl):1238S–1241S
41. Andon MB, Peacock M, Kanerva RL, De Castro JA. Calcium absorption from apple and orange juice fortified with calcium citrate malate (CCM). *J Am Coll Nutr*. 1996;15:313–316
42. Perman JA. Calcium needs and lactose intolerance. In: Tsang RC, Mimouni F, eds. *Calcium Nutriture for Mothers and Children*. New York: Raven Press; 1992:65–75 Carnation Nutrition Education Series, Vol 3
43. Miller JZ, Smith DL, Flora L, Slemenda C, Jiang XY, Johnston CC. Calcium absorption from calcium carbonate and a new form of calcium (CCM) in healthy male and female adolescents. *Am J Clin Nutr*. 1988; 48:1291–1294

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