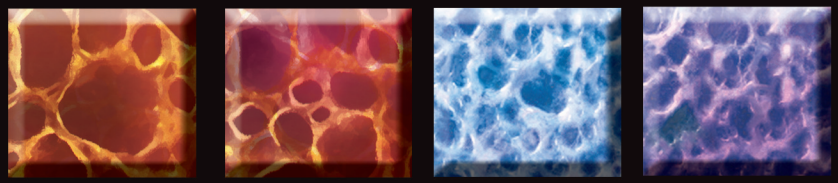

IMPORTANCE OF CALCIUM FOR BONE HEALTH THROUGHOUT THE LIFE SPAN

PRESENTED BY

U.S. Department of Health and Human Services
Office on Women's Health

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National Association of Nurse Practitioners in Women's Health (NPWH)

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This program has been approved for 1.5 contact hours of continuing education by the American Academy of Nurse Practitioners. Program ID: 0607235.

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This program has been reviewed and is approved for a maximum of 1.5 hours of AAPA Category 1 (Preapproved) CME credit by the Physician Assistant Review Panel. Approval is valid for 1 year from the issue date of August 31, 2006. Participants may submit the posttest at any time during that period.

This program was planned in accordance with AAPA's CME Standards for Enduring Material Programs and for Commercial Support of Enduring Material Programs.

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Robert P. Heaney, MD, has disclosed a financial relationship with GlaxoSmithKline and the International Dairy Foods Association. He has received honoraria from Merck & Co., Inc. and Procter & Gamble Pharmaceuticals, Inc.

Saralyn Mark, MD, has nothing to disclose.

Nelson B. Watts, MD, has received honoraria for lectures from Merck, Procter & Gamble Pharmaceuticals, Inc., and sanofi-aventis Pharmaceuticals; is a consultant for Eli Lilly and Company, GlaxoSmithKline, Merck & Co., Inc., Novartis Pharmaceuticals Inc., NPS, Procter & Gamble Pharmaceuticals, Inc., Roche, sanofi-aventis Pharmaceuticals, Servier, and Wyeth; and has received research support from Amgen, Eli Lilly and Company, Merck & Co., Inc., Novartis Pharmaceuticals Inc., Procter & Gamble Pharmaceuticals, Inc., and sanofi-aventis Pharmaceuticals.

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TARGET AUDIENCE

Primary care clinicians, doctors of osteopathy, geriatricians, obstetricians/gynecologists, orthopedists, endocrinologists, rheumatologists, pediatricians, nurse practitioners, physician assistants, and other healthcare professionals with an interest in bone health.

EDUCATIONAL OBJECTIVES

At the conclusion of this program, the participant should be able to:

- Discuss current patterns of calcium intake throughout the lifespan
- Describe how calcium affects bone formation and bone health in various age groups
- Apply strategies to improve calcium intake in various age groups and in populations with low bone mass or osteoporosis

This *Clinical Courier®* is presented by the U.S. Department of Health and Human Services' Office on Women's Health. It is sponsored by the University of Cincinnati College of Medicine and IMED Communications in cooperation with the American Academy of Nurse Practitioners, the American Academy of Physician Assistants, The Endocrine Society, the Illinois Academy of Family Physicians, The International Society for Clinical Densitometry, the National Association of Nurse Practitioners in Women's Health, The National Council on Aging, the National Osteoporosis Foundation, and the Society for Women's Health Research.

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IMPORTANCE OF CALCIUM FOR BONE HEALTH THROUGHOUT THE LIFE SPAN

INTRODUCTION

Bone health is an important determinant of functionality and quality of life. Several factors are critical to bone quality and strength throughout the life span. Some elements of bone health, such as the size and shape of the skeleton, are largely genetically determined; however, lifestyle factors such as diet and physical activity also contribute substantially to skeletal development, size, and strength.[1] By weight, bone tissue is 70% mineral, 8% water, and 22% protein. Calcium comprises 2% to 4% of adult body weight, with more than 99% of the calcium in the body located in the teeth and bones. Approximately 45% of the small fraction of calcium in the blood is bound to plasma proteins, and about 50% is dissociated as free ions.[2]

Adequate supplies of minerals and amino acids are necessary to support continued formation of bone during the remodeling that occurs throughout life.[3] This newsletter reviews the importance of calcium for bone health, with a focus on the need for sufficient calcium intake to achieve high peak bone mass during development, maintain bone at maturity, and minimize bone loss in later life.

CALCIUM THROUGHOUT LIFE

Perhaps because of high calcium intake during primate evolution, humans conserve calcium poorly. Our physiology is fine-tuned to avoid calcium intoxication rather than to offset chronic deficiency, which is more the norm in modern times.[2,4]

Function and Balance

Under normal conditions, the concentration of calcium in extracellular fluid (ECF) is maintained by a combination of the renal calcium threshold, calcium absorbed from food, and adjustments in the balance between bone formation and resorption.[2,5] Calcium is lost from the body every day through perspiration; shed hair, skin, and nails; and excreta (urine and feces).[2] The magnitude of these losses varies between individuals, but for the typical woman at midlife, they average about 200 mg/day.[6] Although exercise is important for increasing and maintaining bone mass, vigorous physical activity with perspiring can more than double the average calcium loss. Results of a study of calcium loss and bone mineral content (BMC) in elite athletes suggest that exercise may be positively related to BMC, but only if calcium intake is sufficient to offset continuous loss of this mineral.[7]

When calcium losses are high and dietary intake is low, skeletal reserves become the body's primary source of calcium.[4] Parathyroid cells sense changes in ECF calcium of less than 1% and respond by releasing parathyroid hormone (PTH).[8]

This hormone acts directly on the kidneys and skeleton and indirectly on the intestine to offset calcium decreases. PTH stimulates the 1-α-hydroxylation of 25-hydroxyvitamin D (25[OH]D) to 1,25-dihydroxyvitamin D ($1,25[OH]_2D$), the hormonally active form of vitamin D.[2,5,9] $1,25(OH)_2D$ plays its role in the mineralization of bone primarily via its effects on calcium metabolism; it stimulates active intestinal calcium absorption as well as intestinal absorption of phosphorus.[10] $1,25(OH)_2D$ and PTH also act together in the distal renal tubule to stimulate the reabsorption of calcium and elevate the renal calcium threshold. Humans filter 7 g of calcium each day, and this reabsorption constitutes a major deterrent to depletion of the body's calcium pool.[10]

PTH induces osteoclast formation and decreases apoptosis; it also affects currently functioning osteoclasts over much shorter intervals to promote resorptive activity and release of calcium from the skeleton. This action likely plays a significant role in shorter-term calcium homeostasis.[5] Both PTH levels and the PTH response to changes in calcium concentrations are increased in the elderly.[11-13] The amount of calcium required to reduce PTH to normal levels for younger adults has not been determined in large-scale studies; however, McKane and colleagues found that it took approximately 2400 mg/day of calcium to reduce parathyroid activity in healthy 65-year-old women to levels typical for healthy premenopausal volunteers.[14]

The bone-remodeling process creates areas of weakness, at least temporarily, simply because the bone that is being remodeled is not contributing fully to the overall strength of the system,[15] so load-bearing stresses are shifted to adjacent bone. Excessive

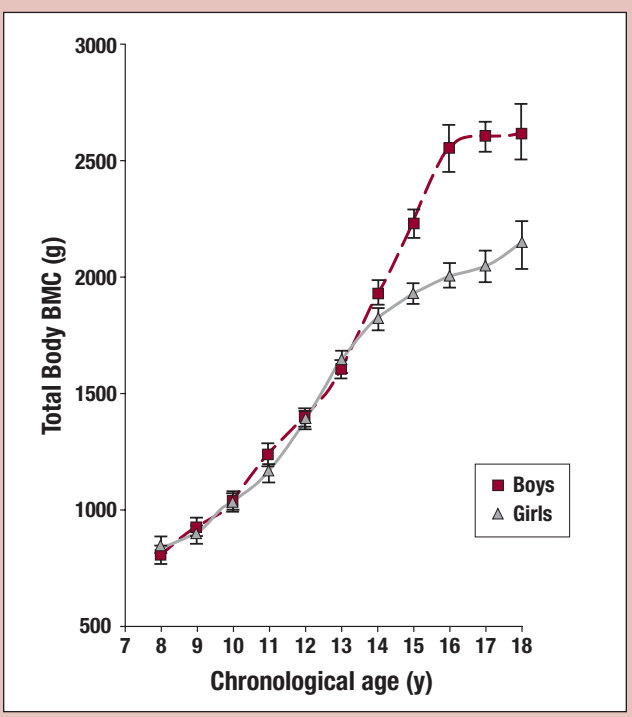
remodeling leads to decreased bone strength out of proportion to the decrease in mass and, hence, to increased fracture risk.[16] Increasing calcium intake results in suppression of PTH activity and a reduction in bone resorption.[12,17,18] Thus, a principal function of adequate calcium intake during adult life is not so much to supply bones with calcium as it is to protect bones from erosion and the consequent skeletal fragility. This view of the inhibition of remodeling (ie, being the primary action of calcium) is consistent with observations that fracture risk reduction with antiresorptive therapies begins as early as 3 months after the initiation of treatment and that most of this benefit is achieved by the end of the first year. This is well before the full effect of treatment on bone mass is realized. These early changes in clinical outcomes are consistent with the rapid suppression of bone remodeling that occurs very shortly after initiation of treatment.[19]

Calcium and Life Stages

Puberty is a time of significant increases in bone growth and mineralization as well as bone turnover.[20] BMC increases during this period, and total skeletal mass approximately doubles by the end of adolescence.[21] The time of maximal peak BMC velocity is approximately 14 years of age in boys and 12 years of age in girls, and in the 3 years of peak skeletal growth, adolescents accumulate about 25% of adult bone mineral **(Figure 1).**[22,23] The main determinants of pubertal gain of bone mass are sex steroids, growth hormone, insulin-like growth factor, and vitamin D and calcium intake.[20,21,23,24] Family history, ethnic background, and physical activity also influence the peak bone mass achieved during childhood and adolescence.[23]

FIGURE 1

Total Mean BMC as a Function of Age



Adapted from Whiting SJ et al. *J Nutr.* 2004;134:696S-700S with permission from American Society for Nutrition.

After peak bone mass is reached, the balance between bone resorption and formation maintains bone mass at a relatively constant level. Calcium intake is important for maintaining this balance in adults.[25,26] However, a study of 146 female twin pairs 30 to 65 years of age showed that daily dietary calcium intake was significantly related to bone mineral density (BMD) after menopause but not before.[27] At about age 50, the balance between bone formation and bone loss changes, and bone mass starts to decline at all skeletal sites.[28] Several factors common with advanced age, including hormone deficiency and decreased vitamin D activation, reduce the efficient utilization of calcium from food.[4] Not surprisingly, inadequate calcium intake is associated with decreased BMD in the elderly.[29,30]

Low bone mass is a generally recognized risk factor for fracture, which in turn results in increased disability and mortality. Approximately half of all white women in the United States will experience osteoporosis-related fractures at some time in their lives.[31] Initial osteoporosis-related fractures occur most often in the wrist or forearm and are associated with increased risk for subsequent vertebral and hip fractures.[32] In the United States, the remaining life expectancy of a community-dwelling 80-year-old patient who has a hip fracture has been shown to be reduced by about 25% (1.8 years).[33] In a prospective study, women with hip fracture were more than twice as likely to die during 4 years of follow-up than were women without hip fracture.[34]

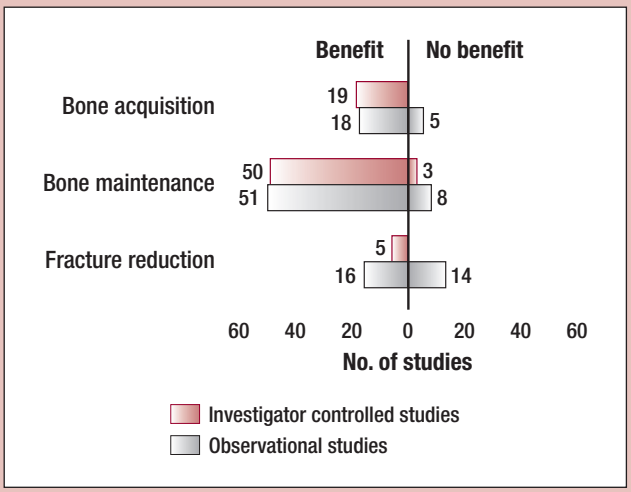
THE IMPORTANCE OF ADEQUATE CALCIUM AND VITAMIN D INTAKE

The risk of osteoporosis and fracture can be decreased substantially by adequate consumption of essential nutrients. The nutrients of greatest importance with respect to osteoporosis are calcium, protein, and vitamin D.[3,19,26,35] In a 3-year study enrolling 389 women and men at least 65 years of age, calcium and vitamin D supplementation had a sustained, significant effect on total body BMD ($P<.001$), with a 50% reduction in the relative risk of first nonvertebral fracture ($P=.02$).[36]

Calcium intake exerts its effect on the prevention and treatment of osteoporosis by 2 principal mechanisms: replacement of obligatory losses of calcium from the body, thereby protecting bone mass, and reduction of the exaggerated bone remodeling that commonly occurs in postmenopausal women and patients with osteoporosis.[37] It has been postulated that adequate calcium intake from childhood on is inversely correlated with risk of later osteoporosis and fracture.[23,38,39] Moreover, common childhood conditions, including lactose intolerance leading to low calcium intake and the use of glucocorticoids for chronic illnesses such as asthma, are risk factors for the development of osteoporosis in both childhood and later life.[23]

FIGURE 2

Published Studies of Skeletal Effects of Calcium Intake, Sorted by Investigative Type and Outcome Measure[15]



Studies have shown that adequate calcium intake significantly decreases bone resorption and increases peak bone mass in young adults.[40,41] Although not every trial has demonstrated a benefit of calcium supplementation in preventing decreases in bone mass in adults,[42] a review of the literature indicated that calcium supplementation was effective in increasing bone mass in the majority of studies **(Figure 2).**[15]

Welten and colleagues' meta-analysis of the relationship between calcium intake and bone mass in premenopausal women and adult men between 18 and 50 years of age followed for at least 1 year indicated a significant positive relationship between these variables in women. Interventional studies in this meta-analysis showed that calcium supplementation of approximately 1000 mg/day for premenopausal women can prevent the loss of 1% of bone per year.[25] These results are consistent with a retrospective dietary survey demonstrating BMC in young adults (25 to 30 years of age) to be directly related to calcium intake through dairy products and with a 5-year prospective evaluation of 156 women 19 to 29 years of age showing the rate of gain in spinal BMD to be correlated with calcium intake.[24,43]

Impact of Low Calcium Intake

Adequate calcium intake in childhood and adolescence is necessary for normal bone accumulation. The majority of peak bone mass is achieved by about 20 years of age, with additional accumulation during the third decade of life. Cross-sectional studies have demonstrated a small positive association between lifelong calcium intake and adult bone mass. Thus, inadequate calcium intake during adolescence and young adulthood may significantly compromise achievement of optimal peak bone mass. It is also important that adequate calcium intake be maintained through adulthood.

Calcium insufficiency due to low intake and reduced absorption often translates into an accelerated rate of age-related bone loss in older individuals. It has been demonstrated that the risk of hip fracture is inversely correlated with calcium intake in both men and women.[44] Secondary hyperparathyroidism, which involves a release of excess PTH or continuous stimulation of the parathyroid glands in response to decreased blood calcium levels, is also a concern with inadequate calcium intake.[45]

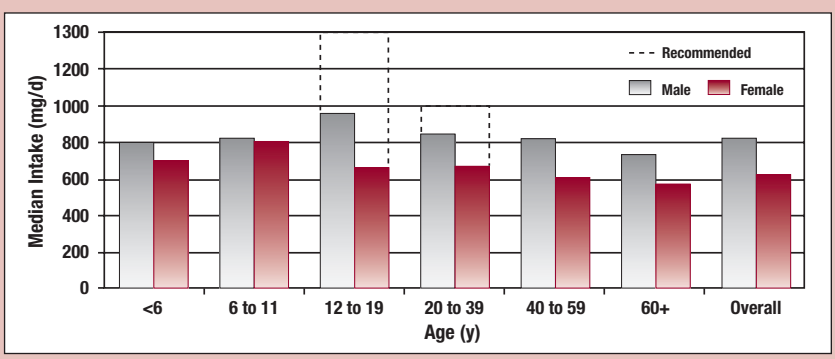
Incidence of Low Calcium Intake

Despite the large body of current knowledge regarding the importance of calcium for bone health, daily practice, by both patients and clinicians, does not always reflect this knowledge.[1] Results of the National Health and Nutrition Examination Survey (NHANES), 1999-2000, show that average calcium intake in the United States fell substantially below recommended levels across both sexes and different ethnic groups and declined substantially with age. For example, the Institute of Medicine (IOM)-recommended calcium intake for adolescents (14 to 18 years of age) is 1300 mg/day, and that for young adults (19 to 30 years of age) is 1000 mg/day.[46] The NHANES found that actual calcium intake for these age groups fell short of these targets, particularly for girls. The median calcium intakes for boys and girls 12 to 19 years of age were 956 and 661 mg/day, respectively. Likewise, median calcium intakes for men and women 20 to 39 years of age were 856 and 684 mg/day, respectively. These values fell to 716 and 563 mg/day for those aged 60 years or older. Across all ages, women fell shorter of the recommended calcium intake than did men **(Figure 3).**[47]

The Survey in Europe on Nutrition and the Elderly; a Concerted Action (SENECA) study included information from people living in 10 European countries. The dietary calcium intake of about one third of the subjects was very low—between 300 and 600 mg/day for women and between 350 and 700 mg/day for men.[12]

FIGURE 3

Daily Median Calcium Intake in the United States, 1999-2000[47]



Long-term adherence to calcium supplementation by patients with osteoporosis is also very poor. The Randomised Evaluation of Calcium OR vitamin D (RECORD) trial found that only about 42% of patients randomized to a calcium supplement or to calcium plus vitamin D were adherent for more than 80% of the time during 2 years of follow-up. Poor adherence was most often associated with gastrointestinal complaints or difficulties taking the tablets.[48] These results suggest that new approaches to calcium supplementation may be required to optimize adherence and realize the full benefits associated with correction of calcium inadequacy.

A variety of substances can affect calcium absorption. Excessive caffeine intake may induce an increase in urinary calcium excretion, and excessive alcohol consumption can cause malabsorption of several nutrients including calcium. Sodium increases urinary calcium excretion as well, whereas phosphorus reduces calcium excretion.[49] Lactose stimulates calcium absorption in infants, but not necessarily in adults.[49] The relationship between calcium and protein is complex, in that protein is beneficial to the body, but it may also increase urinary calcium excretion. However, adequate intake of both protein and calcium are essential for bone formation.[3,49]

Recommendations for Calcium Intake

The importance of adequate calcium intake for maximization of peak bone mass, maintenance of bone mass throughout adulthood, and minimization of bone loss in later life has prompted a number of groups to set forth guidelines for calcium intake. The 1994 National Institutes of Health (NIH) Consensus Development Conference on Optimal Calcium Intake brought together experts from several fields to address the appropriate amount of calcium intake at various stages of life. Calcium requirements vary throughout life, with greater needs during periods of rapid growth in childhood and adolescence, during pregnancy and lactation, and in old age.[44] The values established by the NIH Consensus Development Conference are in general agreement with those set forth by the IOM in 1997; however, the IOM guidelines provide a more specific breakdown of requirements for individuals of different ages. **Table 1** summarizes the IOM recommendations for calcium and vitamin D intake, which were endorsed by the U.S. Surgeon General's 2004 report.[46,50]

The capacity of mechanisms that compensate for low calcium intake declines with age, resulting in increased bone resorption to maintain sufficient calcium levels. As a result, the calcium requirement for skeletal maintenance rises with age; supplemental calcium intakes of 1300 to 1700 mg/day (or 1200 mg/day plus 500 mg/day in diet) may be needed to arrest age-related bone loss and to reduce fracture risk for individuals 65 years of age or older.[4,51] McKane et al found that, at a total intake of 2400 mg/day, both PTH levels and bone remodeling were reduced to healthy premenopausal normal values.[14]

Bisphosphonates are currently the most commonly prescribed form of treatment for patients with osteoporosis.[52] For patients to derive the full benefit of this type of therapy and others, adequate calcium intake is recommended, as the major studies supporting the approval of these agents have included calcium supplementation.[53-58] Thus, it is recommended that patients with low BMD and other fracture risk factors take calcium and vitamin D supplements in addition to bisphosphonates but not at the same time of day.[59] Some reports show that calcium-, aluminum-, and magnesium-containing compounds may interfere with the absorption of bisphosphonates and should not be taken with the bisphosphonate. If they are taken together, the bisphosphonate will be bound by the calcium salt and rendered ineffective.[60,61] Essentially, bisphosphonates should not be taken with anything except water.[60]

Vitamin D

Vitamin D is essential for efficient absorption of calcium.[4,61] Most people, particularly the elderly, have inadequate levels of vitamin D for maintenance of optimal calcium homeostasis. Serum 25-hydroxyvitamin D concentrations of 30 ng/mL or higher have been found necessary for maximal calcium absorption.[62] A North American study with 1536 community-dwelling postmenopausal women receiving treatment for osteoporosis found that serum 25(OH)D levels were lower than 20 ng/mL in 18% of women, lower than 25 ng/mL in 36%, and lower than 30 ng/mL in 52%. The prevalence of suboptimal 25(OH)D levels was significantly ($P \leq .001$) higher among women who

TABLE 1

Adequate Daily Intakes

Age Group	Calcium (mg)	Vitamin D (IU)*
Infants		
Birth-6 mo	210	200
7 mo-1 y	270	200
Children		
1-3 y	500	200
4-8 y	800	200
Adolescents/Young Adults		
9-18 y	1300	200
Men		
19-50 y	1000	200
51-70 y	1200	400
>70 y	1200	600
Women		
19-50 y	1000	200
51-70 y	1200	400
>70 y	1200	600

*Absent adequate exposure to sunlight.

Adapted from Institute of Medicine. Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D, and fluoride. 1997.

took less than 400 IU/day of vitamin D (the amount in a standard multivitamin) than among those who took at least 400 IU/day but was still substantial even among those taking vitamin D supplements.[62]

Vitamin D is produced in the skin following stimulation by sunlight. Previtamin D is isomerized slowly to vitamin D_3 (cholecalciferol), the natural form of vitamin D. Vitamin D_2 (ergocalciferol) is produced from irradiation of ergosterol.[10] For several decades, it was assumed that the 2 forms of vitamin D were equally effective in humans, despite the fact that they have been shown not to be equivalent in other species. Recent studies, however, indicate that vitamin D_3 is substantially more effective than is vitamin D_2 at raising and maintaining serum 25(OH)D levels and is, therefore, the preferable form of vitamin D for treatment.[63,64]

Several factors contribute to inadequate vitamin D levels. These include any circumstance that deprives an individual of sun exposure, such as living in a latitude far from the equator or not going outside regularly (as is often true of older individuals). Summer sun exposure for one-half hour can stimulate synthesis of up to 12,000 IU of vitamin D, but this capability declines with age. Additional risk factors for inadequate vitamin D levels include reduced dietary intake of dairy products and use of medications that affect vitamin D metabolism.[10,36,62,65]

A recent report from the Women's Health Initiative (WHI) has raised questions about current recommendations for the use of calcium and vitamin D. The study results suggested that use of these supplements in women with already high basal calcium intakes offered only limited additional protection against fractures. Specifically, among healthy postmenopausal women, calcium plus vitamin D supplementation resulted in a small but significant improvement in hip bone density ($P \leq .01$). Although use of these supplements did not reduce overall hip fracture incidence significantly, the observed hip fracture rate was less than half of what had been predicted for women of this age. Additionally, in an analysis of subgroups, researchers found that women who were most adherent to the supplemental regimen experienced a 29% decrease in hip fracture, and women 60 years of age or older had a 21% lower risk of hip fracture than did younger women. Probably the most likely explanation for the low response to supplementation was the already high calcium intakes of women entering WHI (approximately 2 times what is typical for women of this age [NHANES data]). As calcium is known to be a threshold nutrient, no response would be expected in individuals already receiving sufficient calcium. In brief, in WHI, there was no low-calcium control group. Additional factors included a high prevalence of obesity and estrogen use—both protective of bone.[66]

STRATEGIES TO IMPROVE CALCIUM INTAKE

Randomized, placebo-controlled trials with healthy children have demonstrated that bone mass and mineral content can be elevated by increasing calcium intake during this crucial developmental period. Increasing consumption of a variety of dairy and other foods that contain high concentrations of calcium is an important first step.[67,68] **Table 2 (page 6)** provides a list of dietary sources of calcium. Clinicians are encouraged to photocopy this information and share with their patients.[71] Additional interventions include home/school milk programs and calcium supplementation.[39,70-74]

An innovative web-based program, titled "Powerful Bones, Powerful Girls," has been developed to help girls increase their calcium intake (http://www.cdc.gov/powerfulbones). This National Bone Health Campaign involves a multiyear national social marketing approach aimed at promoting optimal bone health for girls 9 to 18 years of age to reduce their risk of osteoporosis later in life. The initial focus is on girls 9 to 12 years of age, but the program also targets parents and other adults who influence girls' lives. Key messages emphasize the importance of calcium consumption and regular exercise activity for bone health and describe easy ways to increase both.

Various approaches have been used in an effort to improve calcium intake for older adults, with mixed results. Interventions aimed at changing dietary habits have been shown to increase calcium intake. A 4-month study found that repeated professional counseling resulted in increased dietary calcium intake in a cohort of 150 women with osteoporosis-related fractures. It should be noted, however, that even in the intervention group, calcium intake was only slightly higher (560 mg/day) than in the control group (477 mg/day).[75] A study of 70 elderly men and women showed that nutritional counseling can increase consumption of calcium-rich foods. Although total daily calcium intake was not reported, subjects in this study who received nutritional counseling reported a mean increase of 270 mg/day in their calcium intake.[76]

Supplementation

It should be possible to fulfill daily calcium requirements through diet. However, for individuals who cannot meet their daily requirements with diet alone, supplementation may provide a reliable source of consistent calcium intake.[77]

A meta-analysis of 15 clinical trials that included 1806 postmenopausal women indicated that supplementing calcium intake to correct inadequacy is beneficial in increasing BMD and decreasing fracture risk. Calcium supplementation for at least 2 years was more effective than was placebo in reducing rates of bone loss. The pooled differences in percentage change from baseline were 2.05% for total body BMD ($P=.03$), 1.66% for the lumbar spine ($P<.01$), 1.64% for the hip ($P<.01$), and 1.91% for the distal radius ($P=.01$). These results support the conclusion that calcium supplementation has a positive effect on BMD.[78]

Calcium supplementation may also be effective in prevention of fracture. One of the studies in the above meta-analysis, an 18-month study of 63 patients ranging in age from 62 to 87 years with recent hip fractures, showed that calcium administration (800 mg/day) prevented a decrease in femoral bone density and significantly reduced the risk of vertebral fracture ($P<.05$). Patients in this study received a single 300,000-IU dose of vitamin D at baseline.[79]

TABLE 2

Dietary Source of Calcium

Dairy Foods		
Food	**Calcium (mg)**	**Calories**
Yogurt, 8 oz*		
Plain, nonfat	452	127
Plain, low fat	438	190
Fruit, low fat	345	232
Plain, whole milk	275	138
Cheese		
Romano, 1.5 oz	452	165
Swiss, 1.5 oz	336	162
Ricotta, 4 oz		
Part skim	335	170
Whole milk	255	214
American, 2 oz	323	188
Provolone, 1.5 oz	321	150
Mozzarella, 1.5 oz		
Part skim	311	129
Whole milk	215	128
Cheddar, 1.5 oz	307	171
Muenster, 1.5 oz	305	156
Blue, 1.5 oz	225	150
Feta, 1.5 oz	210	113
Milk, 8 oz		
Fat free (skim)	306	83
Low fat (1%)	290	102
Reduced fat (2%)	285	122
Whole	276	146
Chocolate milk, 8 oz		
Low fat	288	158
Reduced fat	285	180
Whole	280	208
Buttermilk, 8 oz	284	98

Nondairy Foods		
Food	**Calcium (mg)**	**Calories**
Cereal		
Cold, fortified, 1 oz	236-1043	88-106
Oatmeal, instant, fortified, 1 packet	99-110	97-157
Tofu (calcium set), firm, 4 oz	253	88
Soy beverage,† calcium fortified, 8 oz	368	98
Molasses, blackstrap, 1 Tbsp	172	47
Fish, 3 oz		
Sardines in oil, drained	325	177
Pink salmon, canned	181	118
Ocean perch	116	103
Blue crab, canned	86	84
Clams, canned	78	126
Rainbow trout, farmed	73	144
Vegetables, cooked, 4 oz		
Collards	178	31
Soybeans	130	127
Turnip greens	124	24
White beans	96	153
Kale	90	20
Okra	88	26
Soybeans (mature)	88	149
Beet greens	82	19
Bok choi (Chinese cabbage)	79	10
Dandelion greens	74	17

*Nonfat milk solids are added to fat-free and low-fat yogurt to improve texture.

†Must be shaken vigorously; calcium settles on bottom of container.

The above tables are a guide. It is important to check the nutritional labeling on all products.

Adapted from United States Department of Agriculture. Dietary guidelines for Americans. 2005. Appendix B. Food sources of selected nutrients.

In a study of 9605 community-dwelling women and men (median age, 74 years), supplementation with a combination of vitamin D 400 IU/day and calcium 1000 mg/d resulted in a 16% reduction ($P<.025$) in fracture incidence.[80] A study of 583 elderly women indicated that combined administration of calcium (1200 mg/day) and vitamin D (800 IU/day) reversed secondary hyperparathyroidism ($P=.0001$). There was a trend toward reduced loss of hip BMD and hip fracture risk with active treatment.[81] These results are consistent with those of an earlier 18-month study of 1634 women treated with calcium 1200 mg/day plus vitamin D 800 IU/day and 1636 women who received placebo. In this trial, active treatment significantly decreased the risks of hip and all nonvertebral fractures by 43% ($P=.043$) and 32% ($P=.015$), respectively.[51]

Similar results were reported in a 3-year study of 389 elderly men and women who received calcium 500 mg/day and vitamin D 700 IU/day or placebo. Active treatment reduced bone loss in the femoral neck ($P=.02$), spine ($P=.006$), and total body ($P<.001$) and decreased the cumulative incidence of nonvertebral fractures ($P=.02$).[36]

The Patient With Osteoporosis

Many patients taking medication for osteoporosis may not have adequate calcium intake and may not be taking calcium supplements to address this deficit.[66] The efficacy of bisphosphonates and other treatments for osteoporosis, such as selective estrogen receptor modulators and calcitonin, has been enhanced in studies by the coadministration of adequate calcium and vitamin D.[65]

Forgetting to take medication is a common problem for older people and is especially likely for those who take several medications simultaneously.[82] It has been recommended that medications for elderly patients be organized in a way that facilitates appropriate self-administration (eg, color-coding bottles or using medication boxes with compartments that are filled weekly by the patient or caregiver).[83]

Adherence to integrated treatment that includes a bisphosphonate and nutrients can be enhanced by providing both in a manner that makes it easier for patients to remember to take these agents in the correct amounts and at the appropriate times. Bisphosphonate manufacturers have recognized and addressed this problem with new approaches designed to facilitate adherence to combined therapy. Risedronate is now provided as a 35-mg once-weekly tablet copackaged with 6 tablets that provide 500 mg of calcium each, to be taken on the other 6 days of the week.[84] Alendronate is available as a once-weekly tablet that contains 70 mg of alendronate plus 2800 IU of vitamin D.[85]

CONCLUSIONS

Calcium has an important impact on bone metabolism and bone health throughout life. Chronic calcium deficiency resulting from inadequate intake or poor intestinal absorption is one of several causes of reduced bone mass and osteoporosis. Most people, regardless of age, have suboptimal calcium intake. It is vitally important that adequate calcium intake be maintained at all stages of life. Calcium is needed in childhood and adolescence so that optimal peak bone mass can be reached and in adulthood so that the skeletal mass can be maintained and age-related bone loss minimized. Although many factors influence the risk of osteoporosis and fracture, these outcomes are significantly related to calcium intake.

Adherence to practices that improve health outcomes is an ongoing challenge for patients of all ages, especially older patients, and the clinicians who care for them. Strategies to optimize lifestyle and treatment habits may involve nutritional counseling, reminder tools for medication and supplements, and specialized packaging. Clinicians may find that patient-education materials are valuable aids for improving adherence. These are available through authoritative bone health websites, including those of the National Osteoporosis Foundation (http://www.nof.org/), the American Association of Clinical Endocrinologists (http://www.aace.com/), and the National Women's Health Information Center (http://www.womenshealth.gov or www.4women.gov).

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IMPORTANCE OF CALCIUM FOR BONE HEALTH THROUGHOUT THE LIFE SPAN

Continuing Education Credit Information and Posttest Assessment

Importance of Calcium for Bone Health Throughout the Life Span is a self-study newsletter designed for clinicians who manage/treat patients at risk for osteoporosis. Continuing medical education (CME) credit will be awarded to physicians who successfully complete this activity. Participation should take approximately 1.5 hours.

This activity has been planned and implemented in accordance with the Essential Areas and Policies of the ACCME through the joint sponsorship of the University of Cincinnati College of Medicine and IMED Communications. The University of Cincinnati College of Medicine is accredited by ACCME to sponsor continuing medical education for physicians.

Physicians
The University of Cincinnati College of Medicine designates this educational activity for a maximum of 1.5 *AMA PRA Category 1 Credit(s)™*. Physicians should only claim credit commensurate with the extent of their participation in the activity.

Nurse Practitioners
This program has been approved for 1.5 contact hours of continuing education by the American Academy of Nurse Practitioners. Program ID: 0607235.

Physician Assistants
This program has been reviewed and is approved for a maximum of 1.5 hours of AAPA Category 1 (Preapproved) CME credit by the Physician Assistant Review Panel. Approval is valid for 1 year from the issue date of August 31, 2006. Participants may submit the posttest at any time during that period.

This program was planned in accordance with AAPA's CME Standards for Enduring Material Programs and for Commercial Support of Enduring Material Programs.

To complete this activity and receive credit, the participant should:

- Read the educational objectives
- Read and review the newsletter
- Complete the posttest and evaluation form and mail it to:
  The University of Cincinnati
  Office of CME, PO Box 0556
  Cincinnati, OH 45267-0556

  Or fax to: 513-558-1708

  Or submit via the Web at: http://webcentral.uc.edu/cme/

Participants must receive a score of 70% or better to receive credit. Be sure to submit the posttest and evaluation form on or before August 31, 2007. After that date the activity will no longer be designated for credit.

Certificates will be mailed within 4 to 6 weeks. It is recommended that participants keep a copy of their completed materials until they receive their certificate.

Posttest Assessment (Please record your answers in the space provided)

1. Parathyroid cells are capable of sensing changes in ECF calcium as small as __%.
   a. <1 b. 3 c. 5 d. 10
2. Which of the following are actions of PTH?
   a. Stimulation of osteoclast formation
   b. Reduction in osteoclast apoptosis
   c. Increasing the activity of currently functioning osteoclasts
   d. All of the above
3. Which of the following factors contribute to inadequate vitamin D levels?
   a. Lack of sun exposure
   b. Reduced dietary intake of dairy products
   c. Use of medication(s) that affect vitamin D absorption
   d. All of the above can contribute to inadequate vitamin D levels
4. Calcium is lost from the body every day. The magnitude of these losses varies from one individual to another, but for a typical woman at midlife, they average about ___ mg/day.
   a. 100 b. 200 c. 300 d. 400
5. Calcium is known to be a threshold nutrient.
   a. True b. False
6. Analysis of studies in which premenopausal women used calcium supplementation at approximately 1000 mg/day indicated that such treatment can prevent the loss of __% of bone per year.
   a. 1 b. 2 c. 5 d. 7
7. The majority of the body's calcium is located in the:
   a. Blood
   b. Skin
   c. Bones and teeth
   d. Parathyroid glands
8. Calcium intake exerts its effect on the prevention and treatment of osteoporosis by:
   a. Replacement of obligatory losses of calcium from the body
   b. Reduction of the exaggerated bone remodeling
   c. Both a & b
   d. None of the above
9. NHANES data showed that at all ages, women's daily calcium intake is closer to recommended values than is men's.
   a. True b. False
10. The effects of bisphosphonates are enhanced by adequate calcium intake.
    a. True b. False

Posttest Answers **Expiration Date: August 31, 2007**

1.____ 2. ____ 3. ____ 4. ____ 5. ____ 6. ____ 7. ____ 8. ____ 9. ____ 10. ____

Program Evaluation

Please circle the letter that best reflects your opinion of the statements below, using the following scale:

a. Strongly disagree b. Disagree c. Agree d. Strongly agree e. Does not apply

1. The program objectives were fully met.	a	b	c	d	e
2. The quality of the educational process (method of presentation and information provided) was satisfactory and appropriate.	a	b	c	d	e
3. The educational activity has enhanced my professional effectiveness and improved my ability to:					
a. Treat/manage patients	a	b	c	d	e
b. Communicate with patients	a	b	c	d	e
c. Manage my medical practice	a	b	c	d	e
4. The information presented was without promotional or commercial bias.	a	b	c	d	e
5. The program level was appropriate.	a	b	c	d	e
6. I intend to change my clinical practice as a result of the information presented in this CME program.	a	b	c	d	e

Please explain: _____

_____

_____

7. Suggestions regarding this material, or recommendations for future presentations:

_____

_____

_____

Registration Form

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IMPORTANT CME MATERIALS ENCLOSED

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IMPORTANCE OF CALCIUM FOR BONE HEALTH THROUGHOUT THE LIFE SPAN

Additional CME Opportunities are available at the website of
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