

REVIEW

Calcium revisited, part III: effect of dietary calcium on BMD and fracture risk

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Food can be an excellent source of calcium. Dietary calcium is in general as well absorbed as calcium supplements, and exerts the same effects on bone. The main sources are dairy products, but also some vegetables and fruits contain considerable amounts of calcium. Mineral water can serve as a supplement. Cross-sectional, longitudinal and some interventional trials have shown positive effects on bone metabolism, bone density and bone loss. But the effect on fracture incidence is less certain, and that of milk, the most studied dairy product, still unproven.

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Introduction

This review presents the actual knowledge on the effect of dietary calcium on bone in humans. It cannot compete with an exhaustive analysis of the literature by an institute. It does not mention all significant references. However, it quotes meta-analyses and systematic reviews when possible and it refers to relevant recent studies and to pivotal studies from the past. It is strictly focused on nutritional calcium, and to the bone effects in Caucasians. A discussion of the ethnic differences in bone metabolism, bone mass, bone acquisition and dietary calcium need, important for the variation in skeletal health,¹ would exceed the frame of this review.

Food is considered the best source of calcium, and dairy products the best dietary source of calcium, at least for the western-style diets. Only for persons unable to consume enough dietary calcium, supplements should serve as an alternative source. Dietary calcium is associated with a shift in estrogen metabolism toward the active 16-hydroxyl metabolic pathway and with a greater BMD and thus may produce more favorable effects on bone health in postmenopausal women than calcium supplements.² Physical activity is an important confounding factor, not only for calcium supplements as shown before, but also for nutritional calcium.³

Bioavailability of Calcium from Food

The effect of calcium from food on bone depends not only on the amount of calcium ingested, but also on the bioavailability of calcium, which in turn can be indirectly evaluated by the effect on bone. In general, calcium from food is as well absorbed as calcium supplements, but there are differences in bioavailability. Bioavailability depends on absorbability and on the incorporation of the absorbed calcium into bone.

Absorbability depends on the constituents of the given food item. They can affect calcium absorption and/or excretion to varying degrees.⁴ Some decrease calcium absorption, such as oxalic acid (spinach, collard greens, sweet potatoes, rhubarb and beans), or phytic acid (fiber-containing whole-grain products and wheat bran, beans, seeds, nuts and soy isolates). Others enhance calcium absorption, such as lactose and certain caseinophospho peptides formed during digestion of caseins from milk.⁵ This explains—for instance—the high availability of calcium in broccoli and kale,⁶ which is low in oxalate, and the low availability of calcium in spinach,⁷ which is rich in oxalate. Therefore, equivalent calcium contents do not guarantee equivalent nutritional values.

Bioavailability can be assessed by *in vitro* assays, balance studies, classical and isotopic balances, urinary excretion, isotope labeling in the urine, plasma and bones, and by evaluation of bone mineralization and/or by the use of biological bone markers. Therefore, measuring the effect on bone can be considered as an indirect assessment of bioavailability. Reviewing the literature on the effect on bone, as done here, bioavailability becomes crucial when differences in bone effects between different food items with equal calcium content have to be explained. In general, humans absorb about 30% of the calcium present in food, depending on the type of nutrient.⁸

The Effect of the Habitual Calcium Intake on BMD

The effect of dietary calcium on bone density (BMD) is relatively small, although significant. It cannot be demonstrated in the same way as for drugs. Interventional trials, feasible with supplements, are difficult to perform with food over the necessary length of time, and thus are rare. Therefore significant results mostly come from large cross-sectional studies and

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longitudinal surveys or follow-up studies over long periods. They demonstrate associations, but do not prove causal relationships. In addition, even the most accurate assessment of food intake cannot confirm that it truly reflects truly the food intake of the given period, months, years or even the total adult life.

Of the studies on premenopausal women, some showed no positive associations with BMD,⁹ others showed a positive one.^{10,11} In this period of life, calcium intake shows its threshold effect: a very low intake goes along with lower BMD (see part I), while an intake above normal shows no benefit. In the first years after menopause again no correlation between calcium intake and BMD could be found because bone loss is mainly governed by the lack of estrogen.^{12,13}

The Effect of Intervention Trials on BMD by Nutritional Means

Intervention trials are limited in time because the choice of food can hardly be imposed for a long period. For shortening the intervention it is easier to use markers of bone metabolism as endpoints, rather than BMD or fracture incidence. It only needs hours or days or weeks, to demonstrate that a given food item reduces bone resorption. However, such a piece of evidence can justify a larger observational or follow-up study. Very few interventional trials were performed with natural dietary calcium. Most used dairy products, whereas others used calcium-enriched food supplements. They are discussed in the respective chapters.

The Effect of the Habitual Calcium Intake on Fracture Incidence

To demonstrate an eventual effect of nutritional calcium intake on hip fracture incidence is difficult because the effect would be small. It needs large numbers, and the incidence of vertebral fractures cannot be assessed without X-rays. A longitudinal and prospective cohort study on 5022 women out of a cohort of 61 433 subjects, showed that low calcium intake is associated with an increased hip fracture risk,¹⁴ but did not show the opposite.

There are only a few studies examining the anti-fracture effect of dietary calcium. A meta-analysis of the follow-up studies failed to show a significant association between calcium uptake and hip fracture incidence.¹⁵ One later prospective follow-up study in elderly subjects found that a high-calcium intake lowers the hip fracture risk. A quantified 24 h diet recall of 957 men and women aged 50–79 years allowed to conclude, that in the follow-up of 12–16 years the hip fracture risk was inversely associated with dietary intake of calcium, but of no other nutrient (relative risk = 0.6 per 198 mg calcium/1000 kcal).¹⁶ The follow-up of a smaller subset, which was followed for 18 years, showed that age-adjusted mean BMD levels increased significantly with increasing tertiles of calcium intake at all hip sites in women, but not in men.¹⁷

Despite these positive results, it must be concluded from the whole literature that there is little proof that high dietary calcium intake lowers the fracture risk. That low Calcium intake is not included in the list of risk factors of the fracture risk evaluation FRAX shows that the anti-fracture effect of nutritional calcium is not proven. It also speaks for the difficulty to capture one

patient's intake correctly. On the other hand, adequate calcium intake is part of the preventive recommendations.

Interventional Trials by Nutritional Means on Fracture Incidence

Besides calcium supplements, no food item was examined in a prospective interventional trial with fracture incidence as the endpoint. It would need an extremely high number of subjects to show an effect in a time-span during which a nutritional intervention is accepted by the subjects.

Effect of Food Patterns

Nutritional research tries to identify food items with a significant bone effect. This leads to the accumulated evidence of a positive bone effect of many food items. However, nutrition represents a mixture of food with various, sometimes opposing bone effects. Therefore, the knowledge on the effect of patterns of diet comes closer to practical recommendations. However, studies on food patterns are scarce. Nutrition with a high-calcium content has a higher overall health value than a calcium-poor nutrition.¹⁸ Adherence to the Mediterranean diet is linked to a decreased hip fracture risk, not only because of its calcium content, but also because of the content of potassium, vitamin, phytoestrogen, antioxidant, and so on¹⁹ A generally healthy diet, as evaluated by various scores, is not only associated with fewer cardiovascular diseases, but also with fewer hip fractures.²⁰ Hopefully further studies on the bone effects of the overall nutrition of subjects will be performed.

Dairy Products: General Comments

In the western diet, dairy products represent the most important source of nutritional calcium. This does not mean that they are the only source. The daily intake in the paleolithic was estimated to be as high as 1579 mg per day, without any dairy products.²¹ Today the addition of the calcium found in non-dairy food can sum up to an adequate amount. Dairy products make 52% of the total nutritional calcium in elderly Swiss women.²² They make almost 60% of the American dietary calcium,²³ or even about 70%.¹⁵ This difference might be explained by the fact that the assessment of the total calcium intake was more detailed in the Swiss study, since some Calcium is found in almost any nutrient. In Asian countries, calcium from dairies make only 20–23% of the total intake and are difficult to be included in a diet plan.²⁴

Calcium from dairy products is well absorbed (22–27%), and exerts immediately its biologic effects, such as a drop in PTH for several hours.²⁵ However, dairy products also act on bone through other substances, for example, protein and phosphorus.

Very often, dairy products are avoided by fear of increasing the cholesterol intake. However, the content in cholesterol of a mixture of milk, hard cheese and yogurt, which provides 1 g of calcium, has <90 mg cholesterol, which is several times below the allowed limit.²⁶ The eventual negative effects of milk and dairy products are explained by the content of saturated fatty acids. For this reason, low-fat milk, yogurt and hard cheeses are recommended. It should be remembered that cholesterol-lowering diet with no dairy products increases the risk of osteoporosis.²⁷

Effect of Dairy Products on Bone

A review of the literature suggested that dairy products are profitable mainly for younger subjects. Many cross-sectional studies provided non-significant results. However, in one review the overall ratio of favorable to unfavorable effects of the significant studies was 4 in subjects <30 years and 1 in ≥30-year-old subjects,²⁸ which means that calcium in dairies is effective mostly during growth. This positive view was opposed by a study on dietary and dairy calcium intake, which concluded that there is no reason for promoting milk or dairy consumption in children and adolescents.²⁹ However, a more recent review by Heaney³⁰ demonstrates that most of the observational studies and—this is the crucial observation—all interventional trials with dairy food showed a positive association with BMD or BMC.

In children, dairy products exert undoubtedly a positive effect. A meta-analysis of 21 randomized controlled trials (RCTs), published in 2008, showed that an increased intake of dietary calcium and dairy products, with and without vitamin D, significantly increases total body and lumbar spine BMC in children with low base-line intakes.³¹ The effect is sustained into adult life. However, the evidence for later hip fracture risk reduction is weak, as shown in a recent extensive review.³²

When tested in adolescent mothers, dietary calcium was positively associated with total body calcium of the infants.³³

In adults, calcium supplementation with dairies was associated with a higher hip BMD in men, and with a smaller bone loss in men and women in a longitudinal study.³⁴ It also decreased bone loss in premenopausal women.³⁵

Since dairy foods differ in their composition, they also act differently. The 12-year follow-up Framingham Offspring study on 2506 participants showed that the intake of fluid dairy and milk was related with hip, but not spine BMD, that yogurt intake was positively associated with trochanter-BMD, while cheese intake was not associated with BMD. There were suggestive fracture results for milk and yogurt intakes.³⁶ Some cheeses rich in sodium or in fat, as well as cream or ice cream, may even have a negative effect on bone.²⁸ However, ice cream fortified with calcium can be a convenient vector of alimentary calcium, since it lowers bone resorption.³⁷

Dairy intake influences BMD also in the elderly,³⁸ as recently shown in a 10-year Australian follow-up study in subjects over 80 years, where the tertile with the highest intake had BMD values 6–7% higher than the lowest tertile.³⁹ Nutritional calcium intake seemingly is more effective than a high-calcium intake beyond the recommended dietary allowance for elderly women and men, most commonly achieved by calcium supplements.⁴⁰ According to a cross-sectional survey in the US in elderly subjects (NHANES) it does not provide any benefit for hip or lumbar BMD. However, the sensitivity of this survey is questioned by the fact that it could not reproduce the negative effect of a low intake.⁴¹

Milk: General Comment

Milk is by far the most studied dairy food. Calcium from milk and milk products is as well absorbed as calcium supplements,^{42,43} eventually even better, with individual differences.⁴⁴ Milk not only acts on bone in children. It has been recognized already in 1985,⁴⁵ and reconfirmed later, that it inhibits bone turnover and

resorption markers in postmenopausal women^{46–48} and elderly men, and increases IGF-1.⁴⁹

Milk in Children and Adolescents

For infants in the first 6 months of life, human milk provides adequate amounts of calcium and phosphorus, with supplemental minerals coming later from weaning foods. There are no long-term benefits from increasing dietary bone minerals intake in infants and small children.⁵⁰ In adolescent girls, not only BMC and BMD, also serum IGF-1 and serum PTH were tightly associated with milk consumption, but not with other calcium sources.⁵¹ These results usually, but not exclusively, concern the hip BMD. A cross-sectional analysis of young women showed that milk intake during teenage years is also associated with greater BMD total body in young adulthood, whereas current calcium intakes may influence spine BMC.⁵² Several cross-sectional studies have confirmed that regular milk intake during growth goes along with higher BMD in adulthood and at postmenopausal age,^{53,54} perhaps because of a higher peak bone mass or because the regular intake of dairy products in childhood becomes a lifelong attitude.

On the other side, low milk intake in childhood goes along with lower aBMD and smaller bones,⁵⁵ as also seen in a NHANES study, in which women with a low milk intake during childhood and adolescence had less bone mass in adulthood and a greater risk of fracture.⁵⁶

Lactase deficiency is often accused to be responsible for low dairy intake, but lactase genotype and phenotype had no effect on bone mineral density in a high milk consumption population with a prevalent vitamin D insufficiency. Self-perceived milk intolerance leads to self-imposed reductions in milk consumption, increased bone turnover and increased risk of fracture.⁵⁷ However, milk allergy, a serious problem, leads to a low calcium intake and to lower BMD values.⁵⁸

Intervention Trials with Milk or Milk Powder in Children

A group of British children who received milk supplementation grew taller in comparison to a non-supplemented group.^{59,60} This might also be a protein effect. It was calculated from a large follow-up study of children and adolescents that theoretically one glass of milk added (300 mg Ca) to the diet could increase bone accrual by 3 g per year.⁶¹ A 300 ml milk supplement given to adolescent girls over 18 months enhanced the increase of BMD.⁶² Consumption of foods fortified with milk-derived calcium was also effective. In a comparative trial, infants receiving calcium as dairy food had higher total body calcium than those receiving calcium-enriched orange juice.⁶³ Milk intake is probably especially efficient in regions with a low calcium intake. In China, where the nutritional calcium intake is usually low, supplementing the diet of children with milk powder equivalent to 1300 mg calcium enhanced bone accretion.⁶⁴ However, the positive effect of 2 years of school-milk intake⁶⁵ was not evident anymore 3 years after withdrawal, eventually because the calcium intake dropped again to low values.⁶⁶

In general it has to be reminded that the positive effects reported are not only due to the calcium in milk. As emphasized in a study on postmenopausal women, the supplementation with milk improved the nutritional quality of the diet to a greater extent than calcium alone.⁶⁷

Milk in Adults

In later adulthood, dairy products seem to bring less advantages than in children and young adults. According to an extensive review published in 2000,²⁸ there are four times more positive reports than neutral or negative ones in subjects <30 years of age, while the ratio is 1:1 in later adulthood. However, regular lifelong milk consumption was associated with higher BMD values at cortical and trabecular sites in older white women,⁶⁸ and with a higher bone mass in the radius.⁶⁹ In a recent study, the current milk intake in adults was only weakly associated with femoral neck BMD ($P=0.06$).³⁶ However, significant results are mostly to be found in populations with a very low calcium intake.

Intervention Trials with Milk or Milk Powder in Adults

Supplementing the diet of postmenopausal women in China, a country with a low calcium intake, using high-calcium milk powder over 3 years caused substantial reductions in bone loss.⁷⁰ Similar results were provided in postmenopausal women in Malaysia.⁷¹ No effect was observed in a study in young adults,⁷² which was explained by bad compliance, but it is more difficult to show an effect on BMD in this age of relatively stable bone mass, than in growing children or in postmenopausal women or in elderly persons.

Although milk and milk powder increase protein, phosphorus and zinc intake, they lead to less calcium intake than supplements because of lower compliance.⁶⁷

Effect of Milk on Fracture Risk

The effect of milk consumption or of high-calcium diet on fracture risk is not conclusive. One of the largest follow-up study in postmenopausal women, the Nurse's Health Study, showed no association.⁷³ A meta-analysis of the few six prospective cohort studies in women showed no overall association between total milk intake and hip fracture risk, only in the three studies in men the pooled RR per daily glass of milk was 0.91 (close to significance with 95% confidence interval 0.81–1.01).¹⁵ However, being aware of the differences in the quality of nutritional assessments, the result of this analysis has to be taken with caution.

Fortification of Milk

Milk has been found as an appropriate vector for calcium supplementation. The fortification of cow's milk with calcium and/or vitamin D has been widely tested. Calcium-fortified milk over 2 years delayed bone loss and decreased resorption markers in postmenopausal women.^{74,75} Milk fortified with calcium plus vitamin D has been tested in several studies. Since the result of combined supplementation relies essentially on the fortification with vitamin D, these studies are not discussed here. Calcium fortification of milk can optimize the intake in infants, when human milk does not meet the requirements.⁷⁶ In premature infants, fortification of own mother's milk did even improve bone mineralization.⁷⁷

In older men, 18 months after withdrawal the positive effect on BMD was maintained at the femoral neck.⁷⁸

Calcium-fortified soy milk does not match the efficacy of cow's milk.⁷⁹ A product derived from milk, milk basic protein,

has shown to have a positive effect on bone metabolism and BMD.⁸⁰

Yogurt

Yogurt is rich in nutrients which are important for bone, and calcium from yogurt has a high bioavailability. Yogurt is often preferred by subjects with lactose intolerance. In the large observational Framingham Offspring Study of adults, participants with more than four servings of yogurt per week had a higher trochanteric BMD, while the association with femoral neck BMD was weak ($P=0.09$).³⁶ A small intervention study in postmenopausal women with a low dietary calcium intake of <600 mg per day, showed that three servings of yogurt lowered N-telopeptide, a marker of bone resorption, to 22% lower values than the control snack.⁸¹ This is mainly a calcium-effect. That the probiotics in yogurt enhance calcium absorption and have an additional bone effect has almost exclusively been investigated in animals only.

Cheese

Despite the positive effect of lactose on the absorption of milk calcium, calcium in cheese is as well absorbed as calcium in yogurt.⁴ However, this concerns low-fat cheese, namely dry cheese, which is rich in calcium. Since hard cheeses are usually also rich in sodium and when taken regularly increase the sodium intake by several grams, they might not be advisable in some cases.²⁶ There are almost no interventional trials with cheese. Increasing calcium intake by consuming cheese had a stronger effect on bone than calcium tablets with vitamin D in prepubertal girls.⁸² In an other trial in prepubertal girls, cheese appeared to be more beneficial for cortical bone mass accrual than equivalent supplements of calcium or calcium plus vitamin D.⁸³

Mineral Water

Calcium from mineral water is quickly and well absorbed.⁸⁴ Calcium in mineral water is as well absorbed as calcium from milk,^{85,86} or even faster, also in lactose intolerance.⁸⁷

About 200 mg calcium from mineral water lowers PTH and bone resorption markers within 1 h,⁸⁸ and the consumption of only 0.5 l of a calcium-rich mineral water over 6 months lowered PTH, osteocalcin and the bone resorption marker CTX in serum and urine in women with a low calcium intake.⁸⁹ This explains why mineral water, which can contain up to 500 mg of calcium per l, can positively influence BMD as shown in cross-sectional studies⁹⁰ and in follow-up studies, where a calcium-rich mineral water decreased the loss of BMD at the distal radius in postmenopausal women over about 1 year.⁹¹

Therefore, calcium-rich mineral can be used as a calcium supplement. The sulfate-content is of no importance in men. Regular consumption of the rare waters with a very high fluoride content resulted in an elevated BMD.⁹² In accordance with the studies showing beneficial effects of alkalinizing supplements or food on bone, it has been demonstrated that mineral waters can provide an alkali load, which is beneficial for bone,⁹³ and that a mineral water rich in bicarbonate and calcium lowers bone resorption markers even in calcium sufficiency, where calcium-rich water shows no effect.⁹⁴

Mineral waters with a high-calcium content usually contain relatively high concentrations of sulfate and are slightly acidic, while alkaline mineral waters, which are rich in calcium and in bicarbonate, are rare. In this context it has to be reminded that SO₄ probably has no effect on urinary calcium excretion in humans.⁹⁵

Vegetables

When dairy intake is low, for example, in Asian countries, calcium content in plants becomes crucial.⁹⁶ However, it is difficult to obtain sufficient amounts of absorbable dietary calcium in the western-style diets without the inclusion of dairy foods, fortified foods or supplements. In general, vegan sources of calcium may be less bioavailable and, in turn, problematic for ensuring adequate calcium intake.⁹⁷ For example, spinach is rich in calcium, but its high oxalate content reduces calcium absorption to only 5.1%.⁶ On the other side, kale as well as broccoli are rich in calcium and low in oxalate. This explains the high absorption rate of calcium of 40.9%, which is even higher than in milk (32.1%).⁷ Therefore, broccoli is recommended for enriching the nutritional calcium intake as well as other vegetables, such as Asian food with bean curd sheet, shrimp paste and sardines.⁹⁸ However, most of these nutrients are consumed in small amounts. Vegans are anyway at an elevated risk of not meeting their calcium needs, especially during the phase of rapid growth.

Despite this, it can be concluded from a meta-analysis that vegetarianism is not a serious risk factor for osteoporotic fracture.⁹⁹ By including dairy products in their diet, lacto-vegetarians are able to meet the recommended amounts of calcium. The scientific evidence suggests that even being a lacto-vegetarian has greater health benefits and reduced health risks than being a vegan.¹⁰⁰

Grain Products and Nuts

Because of the low calcium content of products made with wheat flour, the high bioavailability of calcium has little nutritional relevance,¹⁰¹ and does not match that of dairy products. In contrast, whole grain products, including rye bread, contain significant amounts of calcium (107 mg, 73 mg per 100 g). When regularly consumed, they can contribute significantly to the total calcium intake. Bran interferes with absorption;¹⁰² leavening improves it.¹⁰¹ Nuts are often indicated as a natural source of dietary calcium. However, they are usually consumed in small amounts. Sesame is recommended for its exceptionally high-calcium content (about 900 mg per 100 g). One spoon of Sesame kernels already provides 90–135 g of calcium. A comparable amount can be found in some Oriental sweets. As another example it can be mentioned that corn tortillas are the second most important source of calcium among Mexican Americans.¹⁰³

Soy and Soy Products

Soy and soy products are mainly recommended for bone health as non-acidifying protein sources, and supposedly useful for their content in isoflavones (a class of plant estrogens). Although they have been extensively tested for their effect on bone health due to their isoflavones, and several studies were considered as positive, meta-analysis and reviews of the

literature came to the conclusion that they had no proven effect.^{104–106}

Soy and some soy products can also be recommended as a source of nutritional calcium, although their calcium content does not match that of dairy products, and that their oxalate content is extremely variable.¹⁰⁷ Soy beans contain almost 300 mg calcium per 100 g, and are rich in oxalate and phytate. However, soy is usually consumed as soy milk or tofu. Soy milk, often preferred to cow milk because of its low-fat content, is low in calcium.¹⁰⁸ For this reason it is usually fortified with calcium, which has a bioavailability equivalent to that of calcium in cow's milk,¹⁰⁹ although former isotope studies favored milk.⁷⁹ Fortified soy milk consumption has been associated with less osteoporosis to the same degree than dairy consumption.¹¹⁰

Tofu contains about 185 mg calcium per 100 mg or several times more, when calcium sulfate was used for its coagulation. The many products made of soy or tofu present very variable calcium and oxalate contents, and their usefulness for bone health must be checked for each commercially available product.

Fortification of food with calcium

When the average intake of calcium in the population falls below the needs, fortification of food with calcium seems to be a solution. It is, however, a difficult approach in public health, because the fortified food has to be consumed regularly by the population, the amount of calcium added to food must be low enough to be harmless in case of high intake, and the availability of the added calcium must be adequate. This last condition is the only one which can be assured in free living adults. In infants, children and in adults, whose intake is supervised in the frame of a study, the intake can be controlled.

The calcium salts used for fortification can differ in their bioavailability. However, most fortifications are made with the usual forms of calcium.¹¹¹ The less-often used calcium sulfate showed a high bioavailability in white bread.¹¹²

Several food items were used as carrier: flour, bread, milk, orange juice, soft drinks, breakfast cereals, snacks rice and rice products,¹¹³ as well as milk and soy milk.

Bioavailability can differ with the choice of the calcium salt for fortification,¹¹¹ and with that of the carrier. Fractional calcium absorption was slightly but significantly greater from fortified bread than from milk,¹¹² and was also better with calcium carbonate than with milk calcium.¹¹⁴ However, the differences are small and of minor importance.

Milk and dairy products are appropriate carriers for infants and children, as discussed above.

Orange juice is also an often used carrier. Calcium in orange juice is as well available as calcium from milk or supplement.¹¹⁵

Other carriers have been used for intervention studies, where the intake can be controlled. The fortification of various food products, such as cakes, biscuits, fruit juices, powdered drinking chocolate, chocolate bars and yogurts, certainly makes the products palatable for children, but can hardly be controlled in a longer study. However, one such study showed in girls with a low habitual intake that calcium-enriched food stimulated BMC and growth.¹¹⁶ In one study the effect on bone was maintained 1 year after discontinuation.¹¹⁷ A 1-year intervention trial with various dietary calcium intakes in young women on oral contraceptives showed a dose-dependent

effect in protecting from loss of BMD and BMC, with 1000–1100 mg calcium having the best effect.¹¹⁸

Food is often enriched with both, calcium and vitamin D,¹¹⁹ which excludes the assessment of the effect of calcium.

Summary

Food can be an excellent source of calcium. Dietary calcium is in general as well absorbed as calcium supplements, and exerts the same effects on bone. The main sources are dairy products, but also some vegetables and fruits contain considerable amounts of calcium. Mineral water can serve as a supplement. Cross-sectional, longitudinal and some interventional trials have shown positive effects on bone metabolism, bone density and bone loss. However, the effect on fracture incidence is less certain, and that of milk, the most studied dairy product, still unproven.

Conflict of Interest

The authors declare no conflict of interest.

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