

## A Review on Effect of Dairy Foods on Bone Health of Adults

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### ABSTRACT

Calcium is essential for bone health at all ages, with a focus on the period of bone development throughout childhood and adolescence as well as the maintenance of bone strength and avoiding the risk of fractures in older people. The best sources of calcium, along with other nutrients like both magnesium and potassium, are found in milk and dairy products. Bone health is greatly impacted by these nutrients. Dairy products can strengthen and maintain bone health and prevent fractures in childhood, adolescence, as well as later in life by increasing daily protein as well as calcium intake. Clinical investigations have demonstrated a strong favourable correlation between dairy dietary consumption and the bone turnover indicators BMC and BMD. Milk, cheese and yogurt are examples of high-protein, high-calcium dairy foods that are recommended for bone health throughout the lifespan to lower the risk of low-trauma fractures. The systematic review covered cross-sectional, case controlled prospective cohort and clinical trials documenting the impact of dairy products on fracture risk, bone mineral density and/or bone mineral content. The review provides an overview of various studies examining the relationship between dairy consumption and bone health in different age groups. It discusses the strengths and limitations of these studies, emphasizing the importance of maintaining a balanced diet rich in dairy products to support overall bone health. However, to this day, no randomized controlled trials have shown the anti-fracture effectiveness of dairy food consumption; instead, this has been assumed through cross-sectional and prospective studies.

**Keywords:** Milk; Dairy products; Adults; Osteoporosis; Bone

## INTRODUCTION

### The significance of dairy products in dietary calcium intake

Dairy foods and dairy products including milk, yogurt, cheese, etc. are considered the main dietary source of calcium around the world. They are encapsulated as one of the five major groups of food in most of the dietary guidelines around the globe. Worldwide, the population consumes calcium ranging from 300 to 1200 mg/day. Dairy products are the main sources of micro and macronutrients like calcium, phosphorous, vitamin D, magnesium and protein with adequate consumption providing maximum bone health. The risk of osteoporosis increases with low bone mineral density [1].

The calcium nutrient intake reference of the UK for adults over the age of 19 is 700 mg/day. Exceeding 1500 mg/day causes stomach pain and diarrhea requirements for calcium intake increase during childhood, pregnancy, lactation and adolescence [2].

Increased fracture frequency is related to removing cow's milk, calcium rich foods and calcium supplements from the diet. Avoiding milk and poor dairy intake leads to lower total body BMC and bone area. The association of dairy dietary intake is not with excessive fat and weight gain because it does not raise the saturated or total fat intake [3].

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## LITERATURE REVIEW

### Recommended calcium intake in adults

Calcium's role in the body is to give the stiffness needed for the skeleton and teeth. Calcium is necessary for the activation of nerve conduction and muscular contraction. Body fluids also

contain calcium, which is involved in protein binding, a protein activator within cells and acts as a signal transmitter. The body needs a lot of calcium at all stages of life (Table 1) [4].

**Table 1:** Recommended calcium intake guidelines for different age groups and gender in mg/day.

Age (year)	USA (IOM)		FAO/WHO		UK (SACN)	
	Estimated average requirement	Recommended dietary allowance	Estimated average requirement	Recommended nutrient intake	Estimated average requirement	Recommended nutrient intake
0.5-3	500	700		500	275	350
4-6	800	1000	440	600	350	450
7-10	800	1000		1300	425	550
<b>Males</b>						
11-14	1100	1300	1040	1300	750	1000
15-18	1100	1300	1040	1300	750	1000
19-24	800	1000	840	1000	525	700
25-50	800	1000	840	1000	525	700
50	800	1000	840	1000/1300	525	700
<b>Females</b>						
11-14	1100	1300	1040	1300	625	800
15-18	1100	1300	1040	1300	625	800
19-24	800	1000	840	1000	525	700
25-50	800	1000	840	1000	525	700
50	1000	1200	840	1000	525	700

**Note:** IOM: USA Institute of Medicine, SACN: UK Scientific Advisory Committee on Nutrition

### Osteoporosis

In osteoporosis increased risk of fracture and skeletal fragility is characterized by low bone mass and many factors are involved in increasing the risk of osteoporosis including sarcopenia, falls, reflexes and inadequate soft tissue padding. 50% risk of osteoporosis is reduced by following proper nutrition and doing weight bearing activities. The common and main fractures are at the sites of the pelvis, humerus and ribs while the major fractures of osteoporosis are at the vertebra, forearm and hip. Osteoporosis is recognized as a pediatric disease with geriatric consequences that's why to promote optimal bone health adolescence is recognized as an awesome time to prevent osteoporosis.  $\geq 90\%$  of peak bone mass is achieved at the time of adolescence before 20 years. In terms of the prevention of

fragility fractures, osteoporosis is an under-screened, underdiagnosed and undertreated disorder [5-10].

### Bone composition and nutrient influence

Inorganic salts, mostly hydroxyapatite and trace amounts of other minerals, including magnesium, sodium, potassium and zinc, are found in bones and are bonded to a protein based natural lattice. Three different types of bone cells-osteoblast, osteoclast and osteocytes produce and maintain bone. There are two different forms of bone trabecular, which is located (15%-25% by volume) at the ends of long bones and within the vertebrae, and flat bones and compact bone (80%-90% by volume), which is a thick and dense layer of calcified tissue that makes the shaft and exterior surfaces of bone. Three endocrine calciotropic hormones, namely dihydroxy vitamin D,

parathyroid hormone and calcitonin regulate the amount of calcium in the serum. When the serum calcium level drops, the parathyroid gland's  $\text{Ca}^{2+}$  detecting receptors activate the release of parathyroid hormone, which acts on the kidney to inhibit the excretion of calcium and on the bone to release calcium. Increases in 25 dihydroxyvitamin concentration operate on the intestine to boost intestinal calcium absorption and on the bone to release calcium even more [11].

More nutrients (calcium, protein, magnesium, phosphorous and zinc) are provided by dairy products per calorie than by any other food group in an adult's diet. Avoidance of milk and milk products in children for the long term leads to more modest height and lower bone mineral mass. Before puberty risk of fracture increases because of low milk intake during childhood.

**Table 2:** Nutritional composition of calcium-rich foods (per 100 g serving).

Calcium-rich foods	K (mg)	Ca (mg)	Protein (mg)	P (mg)
Milk skimmed	156	122	3.4	101
3.7% full-fat milk	151	118	3.3	93
Yogurt, plain low-fat	234	183	5.3	144
Cheddar cheese	98	721	24.9	512
Yogurt, fruit fat	216	169	4.9	133
Cottage cheese non-fat	137	86	10.3	190
Ice cream, soft serve, chocolate	177	131	4.1	116

**Note:** The USDA national nutrient database provided the data for this standard reference

## DISCUSSION

### Calcium intervention in young adults

Dairy consumption has considerable advantages for bone health during development. Pregnant women who take calcium and other micronutrient supplements during their pregnancy are more likely to have children who have higher skeletal growth and bone mass/thickness. A low-dairy diet significantly reduced lumbar spine bone mineral density but not lumbar spine bone mineral content, hip bone mineral density or hip bone mineral content, according to a 15-16 week randomized control trial conducted on females between the ages of 19 and 45. Several studies of calcium supplementation in younger adults showed increased BMD in response to weight loss. Adults are given calcium supplements in a variety of salt forms, including calcium carbonate, calcium citrate, calcium lactate and calcium gluconate. Age related BMD loss is halted at several places, including the femoral neck and around 33% of the radius, but not on the lumbar spine, by consuming milk fortified with reduced-fat calcium and vitamin D<sub>3</sub>. An increase in skim milk, dairy and overall milk consumption was linked to a decreased comparative danger of a high-stress rate among females (average age 21 years), according to a prospective cohort study with a 2-year follow up. A lower incidence of stress fractures and more

The higher lumbar BMC is linked to dietary milk protein but not dietary meat protein. In a 12 month postmenopausal study, women who consumed dairy products containing 1200 mg of calcium and 300 IU of vitamin D (7.5 mcg) showed significantly greater improvements in spine, hip and overall bone mineral density as well as better changes in biochemical markers of bone metabolism and bone mineral thickness than those who only took calcium supplements. In studies of pre-pubertal girls and boys receiving calcium supplements for a year, calcium enriched dietary options significantly increased the buildup of bone mass and the effects persisted for 1-3 years after the calcium supplements were stopped (Table 2) [12].

pronounced bone growth have been related to calcium, vitamin D and protein, which are essential components of milk. Additionally, more significant increases in hip and total BMD were associated with potassium intake. Women in a randomized control study between the ages of 25 and 45 received one of the following complementary therapies in addition to a 500 kcal energy restricted diet three servings of 250 mL of low-fat milk or 250 mL of low-fat milk with micronutrients every day. The findings indicated that the consumption of micronutrients and reduced-fat milk raised the efficacy of an energy limited diet for the treatment of obesity, but that it did not impact blood glucose levels, C-responsive protein, blood lipid levels or pulse rates. Sufficient vitamin D consumption is linked with a decreased rate of osteoporotic hip cracks in ladies who have undergone menopause, according to an 18-year prospective cohort research. A high-calcium diet and milk don't appear to reduce risk. Given that most women don't get the recommended amount of vitamin D. In premenopausal women aged 20-35 years effect of fortified milk supplementation showed that it decreased bone turnover significantly but in this short study phylloquinone does not show an obvious impact on bone turnover (Table 3) [13-17].

**Table 3:** Summary of selected research studies on dairy consumption and bone health.

Study characteristics	Strength	Limitations
Samples present 51 female students, ages 19 to 45 length: 15 weeks To see if consuming enough dairy slows down weight reduction. Decreased bone density Intervention: Milk, yogurt and cheese three to four times per week (1339 mg of calcium daily)	Following weight loss and a decrease in serum osteocalcin concentration, an adequate dairy diet led to noticeably raised lumbar spine BMD (p 0.004)	Small population size short term study. There must be additional factors at work because BMD alone could explain just 19.6% of the entire variance
Postmenopausal women n=66 dairy foods/ placebo; Duration: 30 months	In comparison to the control group, the intervention produced positive changes in the arms, entire spine and total body BMD DG noticed a considerable rise in lumbar spine BMD; however, there was no discernible difference from the control group	The study had a relatively small sample size (n=66) and focused on postmenopausal women aged 55-65, limiting generalizability to other populations. The long-term effects of this intervention beyond 30 months were not assessed
Eighty-two women aged 20 to 35 were randomly allocated into three groups	Demonstrated significant reductions in bone turnover in premenopausal women with fortified milk supplementation	Short-term study duration (16 weeks) may not capture long-term effects
Interventions: Two groups received high-calcium skim milk (1000 mg/d extra calcium) with or without added phylloquinone (80 µg/d), while a control group received no supplementation	Significant decreases in bone turnover markers (cross-linked C-telopeptide of type I collagen, total osteocalcin and type I N-terminal procollagen peptide) in supplemented groups compared to control	Limited information about the potential additive effects of vitamin K supplementation on bone turnover
Investigated the impact of milk supplementation on Bone Mineral Density (BMD) in Chinese women aged 20-35, a population with low dairy consumption	Both groups showed an increase in BMD and a decrease in bone turnover markers over time, indicating the natural process of reaching peak bone mass	Lack of a placebo or control group not receiving any supplement makes it difficult to distinguish the specific effects of milk supplementation
441 community-living women from Hong Kong and Beijing, China, were randomized to receive milk supplements or nothing	Utilized intention-to-treat and per-protocol analyses to assess the impact of milk supplementation	

### Calcium intervention in older adults

A 12-month randomized control study conducted by Moschonis and his colleagues revealed that adding three fortified dairy products calcium-vitamin D, calcium vitamin D plus phylloquinone and calcium-vitamin menaquinone-raised total BMD. In postmenopausal women in the stage of life 55-65 years, the nutrient phylloquinone and menaquinone fortified dairy groups showed an extra significant rise in L2-L4 lumbar spine bone mineral density compared to the control. In a cross-sectional study of white men and women between the ages of 50 and 80, milk consumption is positively connected with BMD at the femoral neck, spine and trochanter. Soft cheese is substantially related to women but not to men, while hard cheese is associated with the femoral, spine and trochanter in men but not in women. Yoghurt did not substantially correlate with women's trochanter or their spine, femoral neck or

trochanter BMD, but it did significantly correlate with their femoral neck and spine. However, neither the spine, femoral neck or trochanter BMD in men nor the spine or the trochanter BMD in women, demonstrated a significant relationship with milk. The spine, femoral neck or trochanter BMD of men and women were not significantly impacted by other milk products. Higher consumptions of yogurt, milk and cheese were protective against trochanter BMD loss among vitamin D supplement users but not among nonusers (n=628), according to the findings of a prospective cohort study of older persons (aged 67 to 93) with a follow-up duration of 4 years. No association was seen between the consumption of dairy products and femoral neck BMD (Table 4) [18-20].

**Table 4:** Summary of selected research studies on bone health and risk factors in postmenopausal women.

Study characteristics	Strength	Limitations
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Participants: 1,215 postmenopausal women (average age 64.3 years) with dietary intake assessed using a validated food frequency questionnaire	Identifies dietary factors associated with osteoporosis in postmenopausal women	The study's findings may not be generalizable to populations with different dietary habits or demographics
Evaluate associations between nutrients, dietary patterns and adherence to Swiss dietary guidelines with bone health among postmenopausal women from the CoLaus/OsteoLaus cohort	Comprehensive assessment of dietary intake and its relationship to bone health	Dietary assessment relies on self-report, which may have recall and reporting biases
To report low-energy fracture incidence in postmenopausal women aged 70 years and explore associated risk factors	Large scale study with a significant sample size of 68,783 postmenopausal women aged 70 years	The study is based on observational data, which cannot establish causation
Assess factors associated with bone health in Malaysians aged $\geq$ 40 years	Provides valuable insights into bone health risk factors in Malaysia, addressing a gap in osteoporosis research in the region	Cross-sectional design limits the ability to establish causation and only shows associations between variables
Data collected from 786 Malaysians in Klang Valley, assessing demography, medical history, dietary and lifestyle practices and using DXA for bone health assessment	The inclusion of both men and women (51.4% women) provides a comprehensive overview of bone health factors	Potential recall bias in self-reported data, as participants provided information on dietary and lifestyle practices
Postmenopausal women (n=141) were assigned to control (n=72) or calcium supplementation (n=69) groups	Shows a significant reduction in bone loss at the lumbar spine and less height loss in the calcium supplementation group	No significant difference at the hip site and weight gain was not significant

## CONCLUSION

Osteoporosis is an infection with numerous risk factors. Despite the significant influence that heredity has on the likelihood of developing osteoporosis, several naturally occurring variables may be changed to reduce risk, including diet and activity. Medical professionals should emphasize the need to eat enough veggies, organic foods and low-fat dairy for the best disease prevention. Even though adults' risk of osteoporotic fracture increases with age, a person's diet throughout a lifetime can have an impact on bone health. Adults can get 25 to 87 percent of the daily necessary quantities of calcium, potassium, vitamin A, vitamin D, protein, iron and magnesium from three to four servings of low-fat milk. Dairy products provide the natural building blocks for bone construction, but other lifestyle choices also have an impact on the formation and maintenance of bone. Physical activity has a greater positive impact on bone thickness and strength when dairy consumption contains enough dietary calcium. Dairy product consumption does not appear to enhance the risk of breaks or cracks. Regular consumption of low- or nonfat dairy products as part of a balanced diet may enhance overall BMD and in some circumstances, reduce the number of cracks in adults. Dairy consumption and markers of bone turnover, bone mineral density and bone content have been positively correlated in clinical studies. The connection between dairy consumption and fracture rate is poorly understood and more research and studies are required to completely comprehend the association.

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