Review Article **Open Access**

A systematic review on assessing the effect of calcium-fortified dairy products on bone mineralization and functionality in adults aged 65 to 80 years

Miriam Hagan*and Chimene Castor

Department of Nutritional Sciences, College of Nursing and Allied Health Sciences, Howard University, Washington DC.

***Corresponding Author**: Miriam Hagan, MS, PMP, Department of Nutritional Sciences, College of Nursing and Allied Health Sciences, Howard University, Washington DC, United States.

Submission Date: October 3rd, 2022; **Acceptance Date:** January 19th, 2023; **Publication Date:** January 31st, 2023

Please cite this article as: Hagan M., Castor C. A Systematic Review on Assessing the Effect of Calcium-Fortified Dairy Products on Bone Mineralization and Functionality in Adults aged 65 to 80 years. *Dietary Supplements and Nutraceuticals* 2023; 2(1): 1-11. DOI: https://www.doi.org/10.31989/dsn.v2i1.1021

ABSTRACT

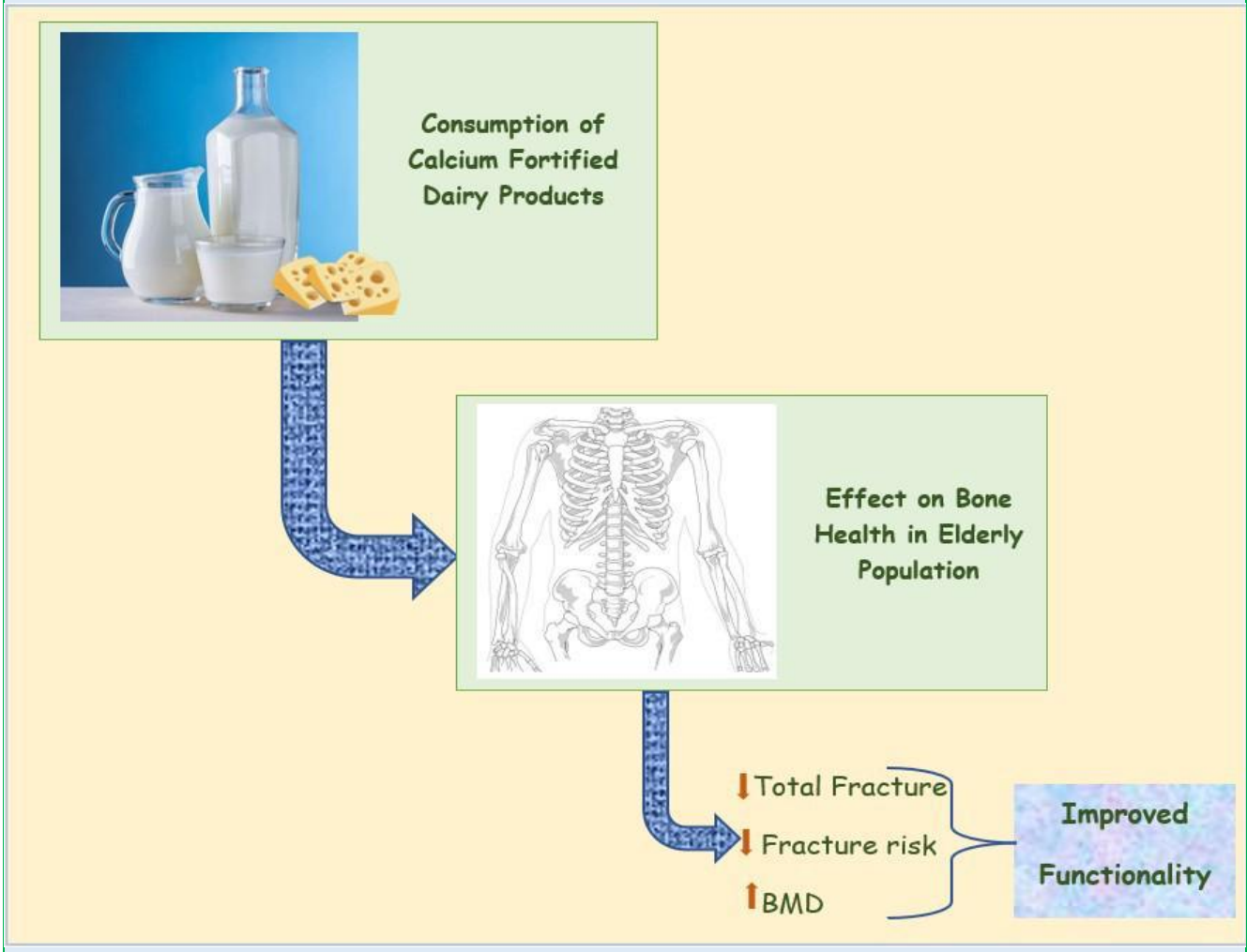
Older men and women are recommended to take at least 1000-1200 mg/day of calcium for bone health and prevention of fractures. Older adults have been encouraged to improve bone health by increasing their calcium intake through food rather than by taking supplements. The Objectives of the Study: To assess the effect of calcium-fortified dairy products on bone mineralization and functionality in adults aged 65 to 80 years. Full text, English only, publications was searched on PubMed and Google Scholar, published within 2011 to 2021. Three search terms were utilized on PubMed, the search resulted in five, five, and four studies. Out of these studies, two, one, and one study respectively, met pre-determined eligibility criteria for inclusion, which summed to four studies. On Google Scholar, the search resulted in 18,600 studies. Out of 60 studies, three studies met the pre-determined eligibility criteria. The total relevant publication summed up to seven studies.

Two studies examined the effect of increasing the RDA of calcium. Four studies examined the effect of dairy consumption on bone health. One study investigated how fermented milk product (FMP) consumption influences bone health in postmenopausal women.

Two studies shown that there was little/no evidence that increasing the RDA through dietary sources or supplements prevents fractures. Four studies shown that there was a benefit on bone mineral density with fortified dairy foods. One study suggested increase intake of yogurt reduces the risk of hip fracture in postmenopausal women.

Regularly consuming diets consisting of milk/dairy products can improve bone mineral density and decrease fracture risk.

Keywords: Dairy, Calcium, Fortified, Bone, Functionality, Older Adults.



INTRODUCTION

The recommendation for older men and women is at least 1000-1200 mg/day of calcium for bone health and prevention of fractures [1]. In Western countries, the average intake in the diet is 700-900 mg/day, which is lower in Asian and African countries, meaning that most older people would need to take calcium supplements to meet these recommendations. Increasing calcium intake through food rather than by taking supplements can improve bone health in older adults [2], because concerns have emerged about the risk-benefit profile of calcium supplements. To prevent osteoporosis, dairy consumption has been recommended by the U.S. Dietary Guidelines for Americans to meet the calcium

requirements. The consumption of three to four dairy servings per day meets the Recommended Daily Intake (RDI) of calcium [3]. A single serving of dairy provides 250 mg of calcium, while a single serving from other food sources requires about 10-12 servings of refined-grain or whole-grain foods, and about five to six servings of vegetables [4], implying that dairy food sources are an excellent source of nutrients that are beneficial to bone health.

Age-related bone loss occurs in both women and men; however, it is accelerated at menopause [5], which makes fracture rates more prevalent in elderly women than in elderly men. According to surveys from North America, more than 80% of women, who are over 50 years, have a dietary calcium lower than the present RDA, which is 1200 mg/day [6-8]. The National Osteoporosis Foundation recommends that men who are within the age range of 50 to 70 years should consume 1000 mg calcium daily and those above 70 years consume 1200 mg, while women over 51 years of age consume 1200 mg calcium/day [9]. Osteoporosis-related fractures and low bone mineral density (BMD) poses a public health burden.

Calcium plays an important role in preventing osteoporosis by acting as an influence to reduce bone loss. This is done by increasing bone mineral density (BMD). Optimizing calcium intake through adequate intake of milk and dairy products can contribute to reducing the burden associated with osteoporosis. Despite dairy products providing more bone-beneficial nutrients such as phosphorus, calcium, zinc, magnesium, protein, and vitamin D than other food sources [10-11], its role in long-term bone health and prevention of fractures has recently been questioned. Some studies suggest that consuming dairy products is associated with higher risk of fractures [12-13]. The effect of dairy product intake on fracture risk remains unclear.

Purpose of the study: The purpose of this study is to assess the effect of calcium-fortified dairy products on bone mineralization and functionality in adults aged 65 to 80 years.

REVIEW OF THE LITERATURE

Effect of Dietary Calcium Intake vs Calcium Supplement on Bone Fractures: Bolland, et al., [14] "reviewed the evidence supporting the recommendation to increase dietary calcium intake to prevent fractures and compared the anti-fracture efficacy of increasing calcium intake through dietary sources with the anti-fracture efficacy of calcium supplements in older adults (>50)". Two trials with dietary sources of calcium as milk powder with a sample size of 200 (vitamin D dose 240 IU/day, calcium dose 800 mg/day) [15], and hydroxyapatite with a sample size of 62 (calcium dose 800 mg/day) [16]. For the randomized controlled trial of milk powder, there was one fracture in the milk group and three in the controls (relative risk 0.33, 95% confidence interval (CI) 0.04 to 3.2; P=0.34). Fractures were reported for the participants receiving hydroxyapatite or calcium supplements. 22 publications were identified that reported associations between dairy intake (n=8), milk (n=14), and fracture outcomes. Most studies reported no association with fracture risk, with 89% showing neutral associations for milk intake and fracture risk, and 85% for dairy intake. A decline in the risk of total fracture was observed at calcium supplement level of less than 800 and 1000 mg/day, (relative risk 0.89, 95% confidence interval 0.81 to 0.96; P=0.004); and vertebral fracture (relative risk

0.86, CI 0.74 to 1.00; P=0.04), but not forearm fracture (relative risk 0.96, CI 0.85 to 1.09; P=0.54) or hip fracture (relative risk 0.95, CI 0.76 to 1.18; P=0.63). In summary, the results show the risk of fracture is not associated with dietary calcium intake, and there is no evidence currently that shows increasing dietary calcium intake prevents fractures. Calcium supplements had unsteady benefits on fracture reduction and the risk associated with its intake outweighs the benefits. As such, recommendations to increase calcium intake for fracture prevention, either with calcium supplements or through dietary sources, should not be considered.

Tai, et al., [17] "investigated studies on dietary sources of calcium or calcium supplements in older adults (aged >50) with bone mineral density (BMD) as an endpoint, to determine whether increasing intake from dietary sources has effects on BMD compared with calcium supplements". Dual energy x ray absorptiometry (DXA) or precursor technology such as photon absorptiometry was used to measure BMD. Results from clinical trials with interventions from dietary sources of calcium such as liquid milk, milk powder, dairy products, and hydroxyapatite preparations (e.g., calcium supplements, co-administered Ca/vit. D, calcium monotherapy) in women over the age of 70 living in the community were analyzed. The mean baseline dietary calcium ingested was less than 800 mg/day; and a calcium dose of more than 500 mg/day; however, most trials used a dose of more than 1000 mg/day for calcium supplements. Increasing calcium intake from dietary sources increased bone mineral density by 0.6-1.0% at the total body and total hip at one year, and by 0.7-1.8% at femoral neck, total body, total hip, and lumbar spine at two years, with no effect at the forearm. Similar results were observed with intake of calcium supplements i.e., BMD increased by 0.7-1.8%, however, after one year there were no subsequent increases observed. The same results were observed in the calcium monotherapy and Ca/vit. D intervention groups. Calcium doses of less than 1000 mg/day and more than 1000 mg/day had no effect on the levels of BMD; the same with doses of less than 500 mg/day and more than 500 mg/day and dietary calcium intake of less than 800 mg/day and more than 800 mg/day. The findings of the results shown that increasing calcium consumption from dietary sources can increase bone mineral density, like the increase observed in calcium intakes from calcium supplements. Thus, increasing calcium intake is unlikely to be beneficial as the effect of fracture may not be significant.

In Rizzoli, [18], combining education, nutrition, and consumption of fortified dairy products for 12 months had more beneficial changes in bone metabolism, such as increased IGF-I, than did calcium supplementation alone in postmenopausal women. The dairy intervention group had significant improvements in the total body, total spine, and pelvis bone mineral density than those on calcium supplements and control. Hip bone mineral density had an improvement, but not the spine BMD in intake of dairy food [19-20].

Effect of Dietary Intake on Bone Health: Fabiani, et al., [21] "provided an estimate of the association between different dietary patterns defined using a posteriori methods and fracture or low BMD risk". The identified dietary pattern included "milk/dairy", "meat/western", and "healthy". The results of the "milk/dairy" pattern were considered relevant for this review. "Milk/dairy" dietary pattern was categorized by a high content of milk

and dairy products, identified as “dairy-fish”, “fruit-milk-whole grains”, “milk-cereal-whole grain”, “dairy-fruit”, “calcium food”, “dairy”, and “milk-cereal” [22-28]. The measurement of BMD and the speed of sound as evaluated by DXA and an ultrasound bone densitometer respectively. The dietary habits and food groups were established using a food frequency questionnaire (FFQ), a twenty-four-hour dietary recall, and a three-day and six-day food record. Regardless of age, the “milk/dairy” group reduced the risk of low mineral density in Eastern countries ($P < 0.0001$). There is an association between the “milk/dairy” patterns and decreased risk of low BMD, which is beneficial to bone health. A greater benefit was observed in the intake of low-fat dairy products. A dietary pattern comprising of milk and/or dairy food groups can decrease fracture risk and improve bone mineral density [29].

Effect of Dairy Products on Bone Health: Wallace, et al., [30], “investigated the role of dairy products and bone health across the lifespan, with a primary focus on fractures, BMD, and bone mineral content (BMC) in older adults (≥50 years)”.

Chee, et al., [31], found that taking two glasses of skimmed milk daily, which contained 1200 mg and 10 µg of calcium and vitamin D respectively, had a greater effect in reducing BMD loss compared to the control at the lumbar spine, total body, total hip. and femoral neck, after two years in Malaysian postmenopausal women aged 55 to 65 years. The study by Chen, et al., [32] observed that intake of milk powder consisting of 450 mg calcium and 400 IU vitamin D had more beneficial effect after two years compared to the control at the lumbar spine, but not hip, in Chinese postmenopausal women aged 50 to 65 years. Lau, et al., [15] established that complementing regular diet with high calcium content milk powder for over two years prevented loss of lumbar spine, total hip, total body, and femoral neck bone mineral density, but not intertrochanter bone mineral density in Chinese postmenopausal women aged 55–59 years. Lau, et al., [33] conducted a follow-up study and discovered that complementing the diet with high calcium content milk powder for over three years had a beneficial effective in preventing bone loss in postmenopausal Chinese females aged 55 to 59 years. Manios, et al., [19] found that intake of calcium and vitamin D fortified dairy products had reduced loss of bone mineral density compared to the control total spine and pelvis, but not total body, lumbar spine, legs, and arms, in postmenopausal white women aged 55 to 65 years. Prince, et al., [34] found that increasing the intake of dietary calcium through milk powder together with physical exercise had reduced loss of bone mineral density compared to the placebo at the ultra-distal ankle, intertrochanter, and trochanter, but not the femoral neck in postmenopausal white women aged 50 to 70 years old. There was no association between dairy intake on fractures in white women over 50-years of age after a ten-year period [35]. Similarly, another study [36] shown no association with the consumption of dairy products and the occurrence of hip fracture in elderly Europeans after an eight-year period. In Biver, et al., [37], milk consumption was related to a smaller decrease of areal bone mineral density, and failure load at the radius. The study by Cumming, et al., [38] shown milk consumption

was related to a lower risk of fracture of the ankle, but not any nonvertebral, vertebral, wrist, proximal humerus, and hip fractures. Feart, et al., [39] observed that reduced consumption of dairy foods such as cheese, yogurt, and milk was associated with significantly increasing the risk of wrist fracture, but there was no effect on the hip or vertebral fractures over eight-years in older adults over the age of 67 years. Zhu, et al., [40] found consuming more than one serving of milk per day can contribute to reduce the severity of fractures in Asian postmenopausal women over 70 years of age. There was a significant beneficial influence of consuming milk on bone mineral content and bone mineral density. The results of the study shown that dairy consumption with adequate calcium content can improve the outcome of physical activity on strength and bone density. A daily healthy habitual dietary pattern of low or nonfat dairy products may be associated with improved bone mineral density of the total body.

Cuesta-Triana, et al., [41] "investigated the effect of milk and other dairy products on frailty and the risk of frailty in the elderly". For this study, a serving of milk, yogurt, and cheese was 250 mL, 125 mL, and 40 g respectively. A lower risk of frailty was found in individuals that consumed more than seven servings of yogurt or low-fat milk per week (Relative risk: 0.52; 95% CI: 0.29, 0.90; P = 0.03) compared to those that consumed less than one serving per week. After adjustment for confounding factors, intake of whole-milk dairy or cheese did not affect frailty status. Intake of more than seven servings of low-fat milk and yogurt per week lowered the risk of frailty. There is a beneficial effect associated with the high intake of dairy products, especially low-fat milk and yogurt on frailty.

Examining a 12-year follow-up of the Framingham Offspring study, Rizzoli, [18] "investigated the associations between the consumption of dairy products and the risk of hip fracture". Studies shown a significant association between dairy food intake, bone mineral density, bone mineral content, and bone turnover markers [42-45]. There is a significant beneficial effect in consuming dairy food on BMD, BMC, and bone turnover markers.

Effect of Fermented Dairy Products on Bone Health: Consumption of kefir fermented milk had no significance in spine bone mineral density, femoral neck, and total hip in patients with a mean age of 63 years diagnosed of having osteoporosis in Taiwan, over a six-month duration [46]. Consumption of fermented dairy products reduced cortical bone loss at nonbearing bone sites in postmenopausal women with a mean age of 65-years over a three-year follow-up period [37]. Fermented dairy product intake was also associated with reduced loss of cortical BMD, area of radius total thickness, and BMD.

Ong, et al., [47] "investigated the association of fermented milk product (FMP) consumption on skeletal outcomes and bone health indicators in postmenopausal women". The health outcomes analysis included the total hip, or the femoral neck, percentage change from baseline in bone mineral density, of the lumbar spine, bone mineral density T-score of the lumbar spine, total body percentage change in bone mineral content, and bone turnover markers. Studies shown a reduced risk of hip fracture was associated with an increased level of

yogurt intake than lower intake of yogurt. 16% of the study population i.e., women within the age range of 72 to 82 years had a sustained incident of fracture on the hip during a follow-up period of over 11 years. A food frequency questionnaire was utilized to assess baseline intake. An intake of no serving and one serving (240 ml) of yogurt was not significant on hip fracture risk [48]. In the Nurses' Health Study involving 80,600 postmenopausal women within the age range of 34 to 60 years were followed for a period of over twenty years; a food frequency questionnaire was utilized during the follow-up period. There was no significant relation between yogurt intake and the risk of a hip fracture in postmenopausal women [49]. Michaëlsson et al., [13] found a 29% reduced risk of hip fracture in Swedish women within the age of 58 to 68 years who had an increased intake of fermented milk products (FMP) i.e., more than two servings per day of yogurt and soured milk, with one serving equaling 200 ml than those who consumed less than a serving. Cheese consumption was not associated with the risk of a hip fracture in women of postmenopausal age. There was no association of hip fracture in women with less than four portions per week of cheese intake compared with women with more than six portions per week of cheese intake in a study of 241 cases of women within the age group of 45 to 74 years hospitalized for a hip fracture [50]. The quantity of cheese per portion was not specified. There was no association between cheese intake of more than one serving per week and hip fracture risk in the Framingham Original Cohort study [48]. In the Nurses' Health Study, consumption of one serving per day of 28 g of cream cheese or hard cheese, or 120 ml of ricotta or cottage cheese, was not associated with hip fracture risk as compared with less than one serving per week of cheese [49]. Grgurevic et al., [51] "investigated factors related to osteoporosis in postmenopausal women in Serbia". Sour cream and yogurt were grouped into one category and with their consumptions, there was no association with the diagnosis of osteoporosis. A lower incident of osteoporosis was associated with daily cheese intake than no cheese intake. Keramat et., al., [52] "assessed the risk factors for osteoporosis in postmenopausal women" within the ages of 50 to 62 years and 48 to 64 years from Iran and India respectively. Daily cheese intake of more than 30 g per day was associated with lower incident of osteoporosis when compared with intake of less than 30 g per day in Iranian women, but not in Indian women. The result of the study showed that there is a protective association of yogurt with the risk of hip fracture in women in postmenopausal age, but not in cheese consumption. In Rizzoli, [18] yogurt intake was associated with hip (trochanter) bone mineral density. Yogurt intake showed a weak positive protective trend for hip fracture, while no other dairy groups showed a significant association [53].

Cost Effectiveness of Consuming Dairy Products: The cost effectiveness to make a case to recommend increased dairy consumption has been estimated in some studies [54-55]. There is at least a 20% reduction in osteoporosis-related health care cost in the United State when consumption of dairy foods is increased to three to four servings per day, which can be interpreted as a savings of $3.5 billion per year [54].

Table 1: Summary of Findings on Dairy Intake and its Effect on Bone Mineralization in Older Adults

Citation		Intervention/Comparator Duration	Sample Size Age Gender Race/Ethnicity	Efficacy Study Summary	Health Outcomes
1.	Bolland, et al., [14]	Milk powder, hydroxyapatite Varied (12mo-19yr)	N= 70 studies >50yrs Mixed gender (Females, and Males) Not stated	"Examined the evidence underpinning recommendations to increase calcium intake through dietary sources or calcium supplements to prevent fractures".	Consumption of dietary calcium is not associated with risk of fracture. The association between calcium consumption and fracture risk is insignificant. Similarly, increasing calcium consumption through dietary sources to alter the risk of fracture may not have a significant effect.
2.	Wallace, et al. [30]	High-calcium skimmed milk powder, kefir-fermented milk, yogurt, control. Varied	N=50 studies >50yrs Male only (10%), Female only (46%) Mixed (44%) Diverse race	"Sought to synthesize the evidence on dairy consumption and bone health across the lifespan, with a primary focus on fractures, BMD, and bone mineral content".	Fortified dairy foods showed a beneficial effect on BMD/BMC over 1-3 years period. Some studies showed a significant effect of dairy consumption on fractures.
3.	Fabiani, et al. [21]	"Milk/dairy" (i.e., "Milk-cereal-whole grain", "Dairy-fish", "Fruit-milk-whole grains", "Calcium food", "Dairy-fruit", "Milk-cereal", & "Dairy". varied	N= 6 studies Age= >20years Mixed Gender race not reported. Not Stated	"Investigated the effect of dietary patterns identified by a posteriori method on low BMD and fracture risk".	The "Milk/dairy" patterns showed a significant effect on bone health, especially the consumption of low-fat dairy products. Regularly consuming a Milk/dairy dietary pattern can reduce fracture risk and improve BMD.
4.	Ong, et al. [47]	Fermented milk products such as yogurt, soured milk, Cheese. Varied (2mo-22yrs)	N=9 studies Age= >55 years Gender= Females Diverse (e.g., Indian, Serbian, Iranian)	"Investigated the evidence on the association of fermented milk product (FMP) consumption on skeletal outcomes and bone health indicators in postmenopausal women".	Increase intake of yogurt reduced the risk of hip fracture. Daily cheese intake showed little protective benefits against osteoporosis.
5.	Cuesta-Triana, et al., [41]	Milk (low-fat milk, whole milk), yogurt, cheese. Duration= 3.5 months	N=1871 Age= >60yrs Gender= 48.4% Males; 51.6% Females Race= Hispanic	"Investigated the effectiveness of dairy product intake for preventing frailty in the elderly population".	Dairy consumption showed a beneficial effect on frailty, especially with increase intake of yogurt and low-fat milk.
6	Tai, et al., [17]	Milk or milk powder, hydroxyapatite. Yogurt, dairy products, calcium supplements Duration= Varied (6mo-7yrs)	N=59 studies Age= >50yrs Gender= 54 studies, females only; 5 studies, mixed (26.8% Males, 73.2% Females) Not stated	"Examined the effect of increased intake of calcium from dietary sources on bone mineral density (BMD), and from calcium supplements".	Increasing calcium consumption from dietary sources increases bone mineral density, as from calcium supplements. The increases observed are steady at about two percent, with no significant effect on BMD after a year.
7	Rizzoli, [18]	Fortified Dairy products, Calcium supplements. Duration= Varied (12months, 12 yrs.)	N= 11 studies Age= >40yrs Gender=91% female only, 9% mixed. Not stated	"Investigated the associations between the consumption of dairy products and the risk of hip fracture".	Sustaining and improving bone health was observed in increasing daily consumption of calcium in dairy products. Consuming dairy foods had a beneficial effect on BMD, BMC, and bone turnover markers.

CONCLUSION

The preponderance of evidence in this review showed that increasing the RDA through dietary sources or supplements can prevent fractures. There was a benefit on bone mineral density with fortified dairy foods. Increased consumption of yogurt showed an association with reduced risk of hip fracture in women of postmenopausal age than with low or no yogurt intake. Dairy products shown a beneficial effect on bone turnover markers and bone mineralization. Fortified dairy products had a greater beneficial effect on bone metabolism than did calcium supplements taken alone. There is a need for recommendations of dairy products to sustain bone mineralization in older adults by the FDA or other nutritional institutes. Overall, regularly consuming a healthy dietary pattern consisting of milk or dairy products can improve bone mineral density and decrease fracture risk.

Further Research: To the best of my knowledge, this review is one of the few publications that assessed calcium content alone from dairy products as it affects bone health in the older population. Most studies were conducted on specific ethnicity (mostly Chinese) female populations. Genetic differences may be a significant concern in extrapolating findings to other ethnic groups. There were more studies on calcium from supplements than from dietary sources, and a lack of data on bone health as the primary outcome in interventional studies. More randomized control trials are required on dietary sources of calcium with bone health as their outcome to draw a conclusion on the effectiveness of calcium-fortified dairy products on bone health. There is a possibility that each variety of cheeses and yogurt preparation may contribute to bone health differently, as different kinds of yogurts and cheese were used in this study.

Abbreviations: RDA: recommended dietary allowance, FMP: fermented milk products, RDI: recommended daily intake BMD: bone mineral density, BMC: bone mineral content, IGF-I: Insulin-like growth factor I.

Conflicts of Interest: There are no conflicts of interest associated with this systematic review.

Author's Contributions: The initiation to the closing phases of this review was conducted by MH. MH conducted research, wrote, and edited the manuscript. CC provided supervision when conducting the research as my faculty advisor.

Acknowledgements: There was no funding supporting this publication. I would like to thank Dr. Njwen Anyangwe of Howard University, Washington DC for her input during this research.

REFERENCES

1. Institute of Medicine. Dietary reference intakes for calcium and vitamin D. National Academies Press 2011. DOI: https://doi.org/10.17226/13050.
2. Bauer DC. Clinical practice. Calcium supplements and fracture prevention. N Engl J Med. 2013; 369: 1537-43. DOI: https://doi.org/10.1056/NEJMcp1210380.
3. USDA. Dietary guidelines for Americans. 7th ed. USDA, US Department of Health, and Human Services 2010.
4. Fulgoni VL, Huth PJ, DiRienzo DB, Miller GD. Determination of the optimal number of dairy servings to ensure a low prevalence of inadequate calcium intake in Americans. J Am Coll Nutr. 2004; 23: 651-9. DOI: https://doi.org/10.1080/07315724.2004.10719407.
5. Reid IR. Menopause. In: Rosen C. J., editor. Primer on the metabolic bone diseases and disorders of mineral metabolism. Wiley-Blackwell. 2013; 165–70. DOI: https://doi.org/10.4103/0971-5916.198664.
6. Institute of Medicine (US) Committee to Review Dietary Reference Intakes for Vitamin D and Calcium. Dietary Reference Intakes for calcium and vitamin D. Ross A. C., Taylor, C. L., Yaktine, A. L., Del Valle, H. B., editors. National Academy of Sciences 2011. DOI:

https://doi.org/10.17226/13050.

7. Bailey RL, Dodd KW, Goldman JA, Gahche JJ, Dwyer JT, Moshfegh AJ, Sempos CT, Picciano MF. Estimation of total usual calcium and vitamin D intakes in the United States. J Nutr. 2010; 140(4): 817-22. DOI: https://doi.org/10.3945/jn.109.118539.
8. Garriguet D. Bone health: osteoporosis, calcium, and vitamin D. Health Rep. 2011; (3): 7-14. PMID: 22106784.
9. Ross AC, Taylor CL, Yaktine AL. & Del Valle HB. Dietary reference intakes for calcium and vitamin D. National Academies Press 2011. DOI: https://doi.org/10.17226/13050.
10. Heaney RP, Abrams SB, Dawson-Hughes, Looker A, Marcus R, Matkovic V, Weaver, C. Peak bone mass. Osteoporosis International. 2000; 11(12): 985-1009. DOI: https://doi.org/10.1007/s001980070020.
11. Heaney RP. Dairy and bone health. Journal of the American College of Nutrition. 2009; 28(sup1):82S-890S. DOI: https://doi.org/10.1080/07315724.2009.10719808.
12. Feskanich D, Willett WC, Stampfer, MJ, Colditz GA. Milk, dietary calcium, and bone fractures in women: A 12-year prospective study. American Journal of Public Health. 1997; 87(6): 992-7. DOI: https://doi.org/10.2105/ajph.87.6.992.
13. Michaelsson K, Wolk A, Langenskiold S, Basu S, Warensjo LE, Melhus H, Byberg L. Milk intake and risk of mortality and fractures in women and men: Cohort studies. BMJ (Clinical Research ed.). 2014; (349): g6015. DOI: https://doi.org/10.1136/bmj.g6015.
14. Bolland MJ, Leung W, Tai V, Bastin S, Gamble GD, Grey A, Reid IR. Calcium intake and risk of fracture: systematic review. BMJ 2015; (351); h4580. DOI: https://doi.org/10.1136/bmj.h4580.
15. Lau EM, Woo J, Lam V, Hong A. Milk supplementation of the diet of postmenopausal Chinese women on a low calcium intake retards bone loss. Journal of Bone and Mineral Research. 2001; 16(9): 1704-9. DOI: https://doi.org/10.1359/jbmr.2001.16.9.1704.
16. Chevalley T, Rizzoli R, Nydegger V, Slosman D, Rapin CH, Michel JP, Vasey H, Bonjour JP. Effects of calcium supplements on femoral bone mineral density and vertebral fracture rate in vitamin-D-replete elderly patients. Osteoporos Int. 1994; 4(5):245-52. DOI: https://doi.org/10.1007/BF01623348.
17. Tai V, Leung W, Grey A, Reid IR, Bolland MJ. Calcium intake and bone mineral density: systematic review and meta-analysis. BMJ. 2015; 351. Doi: https://doi.org/10.1136/bmj.h4183.
18. Rizzoli R. Dairy products, yogurts, and bone health. The American Journal of Clinical Nutrition. 2014; 99(5); 1256S–62S. DOI: https://doi.org/10.3945/ajcn.113.073056.
19. Manios Y, Moschonis G, Trovas G, Lyritis GP. Changes in biochemical indexes of bone metabolism and bone mineral density after a 12-mo dietary intervention program: The postmenopausal health study. The American Journal of Clinical Nutrition. 2007; 86(3):781-9. DOI: https://doi.org/10.1093/ajcn/86.3.781.
20. Moschonis G, Katsaroli I, Lyritis GP, Manios Y. The effects of a 30-month dietary intervention on bone mineral density: the Postmenopausal Health Study. Br J Nutr. 2010; 104:100-107. DOI: https://doi.org/10.1017/S000711451000019X.
21. Fabiani R, Naldini G, Chiavarini M. Dietary Patterns in Relation to Low Bone Mineral Density and Fracture Risk: A Systematic Review and Meta-Analysis. Adv Nutr. 2019; 10(2): 219-36. DOI: https://doi.org/10.1093/advances/nmy073.
22. Denova-Gutiérrez E, Clark P, Tucker KL, Muñoz-Aguirre P, Salmerón J. Dietary patterns are associated with bone mineral density in an urban Mexican adult population. Osteopor Int. 2016; (27): 3033-40. DOI: https://doi.org/10.1007/s00198-016-3633-4.
23. Shin S, Sung J, Joung H. A fruit, milk and whole grain dietary pattern is positively associated with bone mineral density in Korean healthy adults. Eur J Clin Nutr. 2015; (69): 442-8. DOI: https://doi.org/10.1038/ejcn.2014.231.
24. Shin S, Kim SH, Joung H, Park MJ. Milk-cereal and whole-grain dietary patterns protect against low bone mineral density among male adolescents and young adults. Eur J Clin Nutr. 2017; (71): 1101-7. DOI: https://doi.org/10.1038/ejcn.2017.81.
25. Shin S, Joung H. A dairy and fruit dietary pattern is associated with a reduced likelihood of osteoporosis in Korean postmenopausal women. Br J Nutr. 2013; (110): 1926-33. DOI: https://doi.org/10.1017/S0007114513001219.
26. Mu M, Wang SF, Sheng J, Zhao Y, Wang GX, Liu KY, Hu CL, Tao FB, Wang HL. Dietary patterns are associated with body mass index and bone mineral density in Chinese freshmen. J

Am Coll Nutr. 2014; 33: 120-8. DOI: https://doi.org/10.1080/07315724.2013.874897.

27. Park SJ, Joo, SE, Min H, Park JK, Kim Y, Kim SS, Ahn Y. Dietary patterns, and osteoporosis risk in postmenopausal korean women. Osong Public Health Res Perspect. 2012; (3): 199-205. DOI: https://doi.org/10.1016/j.phrp.2012.10.005.
28. Shin S, Hong K, Kang SW, Joung H. A milk and cereal dietary pattern is associated with a reduced likelihood of having a low bone mineral density of the lumbar spine in Korean adolescents. Nutr Res. 2013; (33): 59-66. DOI: https://doi.org/10.1016/j.nutres.2012.11.003.
29. Movassagh EZ, Vatanparast H. Current evidence on the association of dietary patterns and bone health: a scoping review. Adv Nutr. 2017; (8): 1-16. DOI: https://doi.org/10.3945/an.116.013326.
30. Wallace TC, Bailey RL, Lappe J, O'Brien KO, Wang DD, Sahni S, Weaver CM. Dairy intake and bone health across the lifespan: a systematic review and expert narrative. Crit Rev Food Sci Nutr. 2021; 61(21): 3661-707. DOI: https://doi.org/10.1080/10408398.2020.1810624.
31. Chee WS, Suriah AR, Chan SP, Zaitun Y, Chan YM. The effect of milk supplementation on bone mineral density in postmenopausal Chinese women in Malaysia. Osteoporosis International. 2003; 14(10): 828-34. DOI: https://doi.org/10.1007/s00198-003-1448-6.
32. Chen Y, Zhang Q, Wang Y, Xiao Y, Fu R, Bao H, Liu M. Estimating the causal effect of milk powder supplementation on bone mineral density: A randomized controlled trial with both non-compliance and loss to follow-up. European Journal of Clinical Nutrition. 2015; 69(7): 824-30. DOI: https://doi.org/10.1038/ejcn.2015.3.
33. Lau EM, Lynn H, Chan YH, Woo J. Milk supplementation prevents bone loss in postmenopausal Chinese women over 3 years. Bone. 2002; 31(4): 536-40. DOI: https://doi.org/10.1016/S8756-3282(02)00853-0.
34. Prince R, Devine A, Dick I, Criddle A, Kerr D, Kent N, Price R, Randell A. The effects of calcium supplementation (milk powder or tablets) and exercise on bone density in postmenopausal women. Journal of Bone and Mineral Research. 2009; 10(7): 1068-75. DOI: https://doi.org/10.1002/jbmr.5650100711.
35. Aslam H, Holloway-Kew KL, Mohebbi M, Jacka FN, Pasco JA. Association between dairy intake and fracture in an Australian-based cohort of women: A prospective study. BMJ Open. 2019; 9(11): e031594. DOI: https://doi.org/10.1136/bmjopen-2019-031594.
36. Benetou, V, Orfanos P, Zylis D, Sieri S, Contiero P, Tumino R, Giurdanella MC, Peeters PHM, Linseisen J, Nieters A, et al. Diet and hip fractures among elderly Europeans in the EPIC cohort. European Journal of Clinical Nutrition. 2011; 65(1): 132-9. DOI: https://doi.org/10.1038/ejcn.2010.226.
37. Biver E, Durosier-Izart C, Merminod F, Chevalley T, Rietbergen BV, Ferrari SL, Rizzoli R. Fermented dairy products consumption is associated with attenuated cortical bone loss independently of total calcium, protein, and energy intakes in healthy postmenopausal women. Osteoporosis International. 2018; 29(8): 1771-82. DOI: https://doi.org/10.1007/s00198-018-4535-4.
38. Cumming RG, Cummings SR, Nevitt MC, Scott J, Ensrud KE, Vogt TM, Fox K. Calcium intake and fracture risk: Results from the study of osteoporotic fractures. American Journal of Epidemiology. 1997; 145(10): 926-34. DOI: https://doi.org/10.1093/oxfordjournals.aje.a009052.
39. Feart C, Lorrain S, Ginder Coupez V, Samieri C, Letenneur L, Paineau D, Barberger-Gateau P. Adherence to a Mediterranean diet and risk of fractures in French older persons. Osteoporosis International. 2013; 24(12): 3031-41. DOI: https://doi.org/10.1007/s00198-013-2421-7.
40. Zhu Y, Liu S, Chen W, Liu B, Lv H, Zhang X, Zhang Y. Epidemiology of low-energy fracture in Chinese postmenopausal women: Changing trend of incidence since menopause and associated risk factors, a national population-based survey. Menopause. 2018; 26(3): 286-92. DOI: https://doi.org/10.1097/GME.0000000000001211.
41. Cuesta-Triana F, Verdejo-Bravo C, Fernández-Pérez C, Martín-Sánchez FJ. Effect of Milk and Other Dairy Products on the Risk of Frailty, Sarcopenia, and Cognitive Performance Decline in the Elderly: A Systematic Review. Advances in Nutrition. 2019; 10(2): S105–19. DOI: https://doi.org/10.1093/advances/nmy105.
42. Josse AR, Tang JE, Tarnopolsky MA, Phillips SM. Body composition and strength changes in women with milk and resistance exercise. Med Sci Sports Exerc. 2010; (42): 1122-30. DOI: https://doi.org/10.1249/MSS.0b013e3181c854f6.
43. Bonjour JP, Benoit V, Rousseau B, Souberbielle JC. Consumption of vitamin D- and calcium-fortified soft white cheese lowers the biochemical marker of bone resorption TRAP 5b in postmenopausal women at moderate risk of osteoporosis fracture. J Nutr. 2012; (142): 698–703. DOI: https://doi.org/10.3945/jn.111.153692.

44. Kruger MC, Schollum LM, Kuhn-Sherlock B, Hestiantoro A, Wijanto P, Li-Yu J, Agdeppa I, Todd JM, Eastell R. The effect of a fortified milk drink on vitamin D status and bone turnover in post-menopausal women from Southeast Asia. Bone. 2010; (46): 759-67. DOI: https://doi.org/10.1016/j.bone.2009.10.036.
45. Thorpe MP, Jacobson EH, Layman DK, He X, Kris-Etherton PM, Evans EM. A diet high in protein, dairy, and calcium attenuates bone loss over twelve months of weight loss and maintenance relative to a conventional high-carbohydrate diet in adults. J Nutr. 2008; (138): 1096-100. DOI: https://doi.org/10.1093/jn/138.6.1096.
46. Tu MY, Chen HL, Tung YT, Kao CC, Hu FC, Chen CM. Short-term effects of kefir-fermented milk consumption on bone mineral density and bone metabolism in a randomized clinical trial of osteoporotic patients. PLoS One. 2015; 10(12): e0144231. DOI: https://doi.org/10.1371/journal.pone.0144231.
47. Ong AM, Kang K, Weiler HA, Morin SN. Fermented Milk Products and Bone Health in Postmenopausal Women: A Systematic Review of Randomized Controlled Trials, Prospective Cohorts, and Case-Control Studies. Adv Nutr. 2020; 11(2): 251-65. DOI: https://doi.org/10.1093/advances/nmz108.
48. Sahni S, Mangano KM, Tucker KL, Kiel DP, Casey VA, Hannan MT. Protective association of milk intake on the risk of hip fracture: results from the Framingham Original Cohort. J Bone Miner Res. 2014; 29(8): 1756-62. DOI: https://doi.org/10.1002/jbmr.2219.
49. Feskanich D, Meyer HE, Fung TT, Bischoff-Ferrari HA, Willett WC. Milk and other dairy foods and risk of hip fracture in men and women. Osteoporos Int. 2018; 29(2): 385-96. DOI: https://doi.org/10.1007/s00198-017-4285-8.
50. Tavani A, Negri E, La Vecchia C. Calcium, dairy products, and the risk of hip fracture in women in northern Italy. Epidemiology. 1995; 6(5): 554-7. DOI: https://doi.org/10.1097/00001648-199509000-00017.
51. Grgurevic A, Gledovic Z, Vujasinovic-Stupar N. Factors associated with postmenopausal osteoporosis: a case-control study of Belgrade women. Women Health. 2010; 50(5): 475-90. DOI: https://doi.org/10.1080/03630242.2010.507656.
52. Keramat A, Patwardhan B, Larijani B, Chopra A, Mithal A, Chakravarty D, Adibi H, Khosravi A. The assessment of osteoporosis risk factors in Iranian women compared with Indian women. BMC Musculoskelet Disord. 2008; (9): 28. DOI: https://doi.org/10.1186/1471-2474-9-28.
53. Sahni S, Tucker KL, Kiel DP, Quach L, Casey VA, Hannan MT. Milk and yogurt consumption are linked with higher bone mineral density but not with hip fracture: the Framingham Offspring Study. Arch Osteoporos. 2013; (8): 119. DOI: https://doi.org/10.1007/s11657-013-0119-2.
54. McCarron DA, Heaney RP. Estimated healthcare savings associated with adequate dairy food intake. Am J Hypertens. 2004; (17): 88-97. DOI: https://doi.org/10.1016/j.amjhyper.2003.08.008.
55. Lötters FJ, Lenoir-Wijnkoop I, Fardellone P, Rizzoli R, Rocher E, Poley MJ. Dairy foods and osteoporosis: an example of assessing the health-economic impact of food products. Osteoporos Int. 2013; (24): 139-50. DOI: https://doi.org/10.1007/s00198-012-1998-6.