

Research

Can Vegans Have Healthy Bones? A Literature Review

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Abstract

Introduction: Osteoporosis is a pervasive disease with a high price tag. Over 200 million people worldwide have the disease. Major health initiatives include recommendations for dairy products. However, approximately two percent of Americans choose to follow a vegan diet. Despite the general acceptance of dairy products as a necessary component of a healthy diet to prevent osteoporosis, some studies have demonstrated that a vegan diet may be equivalent, or even superior, to this accepted wisdom. This paper explores whether the potential deficiencies of following a vegan diet result in an adverse effect on bone health.

Methods: Literature search was performed using PubMed, Mantis, and the Cochrane Library databases. Search terms included osteoporosis, vegan and vegetarian and bone health, in combination with one another. Articles that discussed the impact of vegetarian or vegan diets on osteoporosis were selected.

Results: Vegan diets are at risk for deficiencies in protein, calcium, and vitamin D3. Dairy products are a common source of calcium in the American diet. The relationships among vegan diets, bone loss, and fracture rates have been equivocal.

Discussion: The importance of protein, calcium, and vitamin D on bone health is well established. Although at risk for deficiencies in these areas, some literature suggests that well-balanced vegan diets may be adequate to maintain bone health. Higher than normal intakes of fruits and vegetables have been shown to support healthy bones. Since vegan diets are ideally high in fruit and vegetable intake, this may explain these findings.

Introduction

Osteoporosis is a pervasive disease with a high price tag. Somewhere between 10 and 25 billion dollars are spent annually in the United States for treatment of osteoporosis.^{1,2} Additionally, a good deal more is spent on its consequences, such as pathological fractures and disability. It is estimated that over 200 million people worldwide have osteoporosis.¹ Major health initiatives have been developed to stem the tide of this disease, including dietary and lifestyle recommendations.³ Most dietary recommendations include dairy products as an integral part of prevention and treatment.^{2,3}

However, osteoporosis appears to be more prevalent in the developed countries where dairy products are abundant and well utilized by the population.^{4,5} A recent cohort study in Sweden found that there was no risk reduction in fracture rate with milk intake, and that, in fact, increased milk intake was associated with increased mortality.⁶ This seems to contradict the dictum of the need for dairy products. The question arises as to whether dairy products are necessary, or even advisable, for the prevention of osteoporosis.^{4,5}

Loss of bone density resulting in osteoporosis is a major health concern in the United States, and as many as two percent of Americans are choosing a vegan diet, which is free of all animal products, including dairy.^{7,8,9,10} Some studies have shown that these types of diets may be equivalent, or even superior, to the accepted wisdom of the need for dairy.⁸ The importance of determining whether or not a vegan diet can support bone health becomes significant. This paper will explore whether vegans can have healthy bones despite the potential deficiencies of protein, calcium, and vitamin D.

Methods

A literature search was performed using the PubMed, Mantis, and Cochrane Library databases. Search terms included “osteoporosis,” “vegan,” “vegetarian,” “protein,” “plant protein,” “calcium” and “vitamin D.” Each of the other search terms was combined with either “vegan” or “vegetarian.” References were selected by their applicability to the relationship between diet and osteoporosis, especially in regard to vegan and vegetarian diets.

Results

Osteoporosis is defined as a “metabolic bone disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in fracture risk”.^{3,11} It is estimated that one in three women and one in twelve men over 55 years globally will suffer from osteoporosis in their lifetime.¹² This ratio is expected to increase as the population ages.³ Females are affected four to one, with a decrease in this ratio with increasing age.⁴ Pathogenesis of osteoporosis is multifactorial,^{12,13} and is strongly influenced by lifestyle.^{12,14} Diet is one of the predominant controllable factors.^{15,16n} This paper, however, is primarily concerned with the calcium, protein, and vitamin D factors associated with a vegan diet.

Vegetarian, including vegan, diets have recently experienced an increase in popularity.^{9,17} In 2004, researcher New reported an estimated 4.3% of the UK being vegetarian,¹¹ and in 2006 it was estimated that 1.4% of the American population was vegan.⁹ A healthy vegetarian diet of any type includes a variety of plant foods in abundant quantities.¹⁸ Vegetarian diets are high in fiber and most vitamins and

minerals, generally low in total and saturated fat, and high in a variety of phytochemicals and protective compounds.¹⁸ Vegetarian diets are associated with some health benefits, including decreases in cardiovascular risk, hypertension, and obesity.^{7,9,11,19} This may be explained by its higher content of fiber, folate, vitamins C and E, potassium, magnesium, and many phytochemicals,^{9,11,19} as well as lower caloric content.⁹ Additionally, people who follow vegan diets are thinner, have lower serum cholesterol and lower blood pressure.⁹ However, they are more at risk for deficiencies of certain nutrients, including vitamins B-12 and D, calcium, protein, and specific long-chain omega-3 fatty acids.^{9,15}

Among their other physiological functions, calcium, vitamin D, adequate protein, vitamin K, magnesium, and potassium are necessary for healthy bones.^{9,11} Vegan diets provide significant amounts of vitamin K, magnesium, and potassium, as well as plant sources of protein.^{9,11,15} However, potential deficiencies of protein, calcium, and vitamin D have been identified in vegan diets, and are of particular concern in terms of osteoporosis risk.^{11,16,20}

Calcium

Dairy products are the primary source of calcium in the American diet.^{4,5} Intake of dairy products has been linked with improvement in bone health in children and adolescents and with increased lumbar spine bone density in adult women.⁵ Low calcium intake has been associated with increased fracture rates.¹⁵ Some observational studies have found that milk avoidance is associated with increased fracture risk and decreased bone mineral content.²¹

However, Lanou points out that osteoporotic fracture rates have been found to be highest in countries that consume the most dairy, calcium, and protein.⁷ This has been described as the “calcium paradox”.⁷ As a possible explanation, the World Health Organization noted “the adverse effect of protein, particularly animal protein, might outweigh the positive effect of calcium intake on calcium balance.”⁷ A study performed in 2012 comparing vegan Buddhist nuns to community-based omnivores, found that there was no difference in bone loss between the two groups.¹⁷ This was despite the finding that dietary intake of calcium was lower in the vegan population.¹⁷ In this study, the BMD was expressed as T-scores, which were based on the Thai reference database. The T-score compares the measurement in question to the peak bone mass at ages 20 to 30. In addition, no significant differences were found between the vegans and omnivores, in terms of height, weight, or age. Covariant analysis was utilized, with the covariates being BMD, age, body weight, bone turnover markers, vitamin D and nutritional factors. In this study physical activity was not considered in the analysis, which was a weakness of the study.

Other studies have also shown lower calcium intake in vegan diets.^{20,22} The effect of lower calcium intake on fracture rate and bone mineral density (BMD), however, is unclear.¹⁵ One meta-analysis showed negative association of animal protein with bone fracture risk and positive with bone health in subjects who were calcium replete.²³ Higher fruit and vegetable intake has been associated with better BMD in some studies.²⁴

In contrast, Craig found that inadequate calcium (and protein) was associated with bone loss and fractures in the elderly.⁹ These contrasting findings may be partially explained by the potential differences in the nutrient density and plant food contents of the diets in the dissimilar populations studied. Many omnivorous, community-dwelling elderly may not consume foods found in a vegan diet, such as beans, leafy greens, and other vegetables. These foods may provide calcium that is more efficiently absorbed than from dairy products⁷ or that contributes less to calcium loss. It is possible that

a poorer quality of the overall diet, combined with low calcium intake, may contribute to increased fracture and bone loss rates. These dichotomous reports reflect the complexity of the issue of dietary effects on bone health.²⁵ Also, there may well be other factors that partially explain these discrepancies; but they are outside the scope of this paper.

Protein

Although protein is part of the bony matrix, the type and the amount of dietary protein necessary for bone health are controversial.¹¹ Adequate protein has been shown to be an important component of skeletal robustness.²⁶ Non-collagenous protein makes up 10-15% of the bony matrix.²⁷ Adequate protein provides amino acid precursors necessary for bone structure and anabolic support of bone structure.²⁸ In particular, insulin-like growth factor (IGF-1) may participate in bone growth and maintenance.²⁸ Inadequate protein may contribute to accelerated bone loss through both mechanisms.

In addition, protein increases dietary calcium absorption and bioavailability,^{28,29} while high protein diets may increase urinary calcium loss. The effect of animal versus plant protein has also been studied. A recent meta-analysis found both positive and negative effects of animal protein, but total protein appeared to have at least a neutral effect, and at best a positive effect.²⁹

In 2008 it was found that higher consumption of foods rich in protein was associated with a lower risk of wrist fracture, regardless of whether it was animal or vegetable protein.²⁶ However, epidemiological studies have shown mixed results regarding the effect of protein on bone loss and fracture risk.¹¹ A comparison of Taiwanese vegetarians and non-vegetarians did not demonstrate differences in BMD despite the lower protein intake of the vegetarians.¹⁶ In Ho-Pham's study of Buddhist nuns, animal protein and animal lipids had a negative effect on bone density.¹⁷

In other studies, higher levels of dietary protein have been shown to result in urinary calcium loss and negative calcium balance and bone loss.¹¹ Specifically, a higher intake of animal protein compared to vegetable protein has been shown to accelerate bone loss.²² This result was attributed to the effects of animal protein on bone metabolism related to the acid-alkaline balance.²² However, despite the suggestion that modern diets increase systemic acid load, resulting in accelerated bone loss, results from recent meta-analyses did not find a direct link between dietary acid load and bone loss or osteoporosis.^{28,30}

Vitamin D

Vitamin D is also necessary for bone health.^{9,17,20} The two primary sources of vitamin D₃, (25-Hydroxy Vitamin D or 25(OH) D) are consumption of animal products and in-vivo synthesis via exposure to natural light.²⁰ In the case of vegans, their primary source is natural light. This becomes a significant problem for those who are elderly, dark-skinned, or live in northerly climates, especially in the colder months.²⁰ Serum levels of 25(OH)D in vegans have demonstrated conflicting results, with some showing lower vitamin 25(OH)D levels in vegans, and others, higher.^{17,20} Ho-Pham et al. found low levels of 25(OH)D in their study on Buddhist nuns.¹⁷ Seventy five percent of the vegan participants had 25(OH)D levels that were defined as insufficient, and more than one quarter were found to be clinically deficient in 25(OH)D.¹⁷ However, despite this finding, there was no difference in bone loss between the vegan and omnivore groups.¹⁷ This raises the question of how the vegan participants were able to minimize bone loss despite low levels of vitamin D₃.

Discussion

The importance of protein, calcium, and vitamin D in bone health is generally well accepted. All three are interrelated in regard to bone integrity, with sufficiency of all three being necessary for optimal skeletal integrity.²⁷ However, whether or not a vegan diet can adequately supply these nutrients in sufficient amounts to maintain healthy bones is controversial.^{9,10,15,20,31} It has been suggested that the higher levels of fruits and vegetables typically present in a vegan diet account for these ambivalent findings.^{32,33} A beneficial effect of fruit and vegetable intake on indices of bone health has been established.^{32,33} The Dietary Approaches to Stopping Hypertension (DASH) and DASH-Sodium intervention trials found that increasing fruit and vegetable portions, from 3-6 to 5-9 daily, had a positive effect on reducing urinary calcium excretion.³³ Other literature has also reflected the positive benefits of fruits and vegetables on bone health.^{20,32,33} These results probably reflect the addition of other substances in the fruits and vegetables that are necessary for adequate and superior bone health, such as minerals and phytonutrients.

The role of adequate protein in a healthy bone matrix is also well established.^{9,11,32} Adequate dietary protein enhances the production of IGF-1, which in turn increases the absorption of calcium in the intestinal lumen.²⁷ Studies have shown that, especially in the elderly, protein is often deficient.³² However, the amount of protein that is “adequate” and the amount that is too much remain unclear.^{9,26,32} The source of the protein may also be important, in terms of what is enough and what is excessive. Either vegetable or animal based protein appears to be adequate for prevention of fractures and underpinning of a strong bony matrix.^{7,17,26} A cohort study over a 25-year period in peri- and postmenopausal females demonstrated reduced wrist fracture rates, regardless of whether the protein was vegetable or animal.²⁶ In fact, Sellmeyer reported that a higher vegetable protein intake compared to animal protein resulted in a lower rate of bone loss.²² Some authors suggest that the recommended protein levels for bone health are actually too low, and that increased intake of fruits and vegetables may attenuate the possible increased urinary calcium loss from the higher protein levels.³² A systematic review by Pedersen suggests that, although the evidence is not conclusive, bone health and density seem to be improved with higher levels of protein intake, although not specifically of animal or vegetable origin.²⁹

In past studies, animal based protein was associated with increased calcium excretion, which was thought to contribute to bone loss.^{10,11,32} However, as demonstrated in recent meta-analyses, this correlation may be faulty, as increased urinary calcium secretion may have to do with other metabolic factors, and may not be directly related to bone loss, thus not reflecting increased risk of osteoporosis.³⁰ One of the reasons this relationship has not been firmly established is that high protein intake may well cause increased urinary calcium loss, but it also seems to increase its absorption or bioavailability.²⁹ Therefore, the divergent effects may cancel each other out. When discussing protein in western diets, the issue at hand may be that the diets are deficient in fruits and vegetables, and not that they are too high in protein.^{10,32,33}

In addition to protein, adequate calcium is integral to skeletal health.^{4,15} However, the literature suggests that, in the presence of plant-based food sources, the amount needed may be less than previously thought.^{17,33} Recent findings suggest that large amounts of supplemental calcium may have some adverse effects.³⁴ Dairy products do contain significant amounts of calcium, and there is substantial literature that supports the use of dairy products in producing and maintaining bone health.^{4,5,15,32} A vegan diet, which is dairy free, may not always be associated with accelerated bone loss,

as might be expected.^{17,35} In addition, some epidemiologic studies have shown an inverse effect of animal protein, including dairy, on bone health.^{6,36} There is a need to investigate further the impact of animal sources of calcium versus plant sources on maintaining healthy bones and prevention of osteoporosis.

Vitamin D is necessary for absorption of calcium, and thus is very important to maintain bone density. Vegan diets have been found to be deficient in this necessary vitamin, thus creating a risk of insufficiency among vegans.^{9,35} Despite this, Ho-Pham found no difference in bone health between vegans and omnivores, despite significantly low levels of vitamin D in the vegans.¹⁷ Perhaps this study was not long enough to show an adverse effect. However, a more recent animal study showed that an edible mushroom, exposed to proper lighting, is able to supply vitamin D₂ and, thus, may help to upgrade a vegan diet.³⁷ Other studies have reported ambiguous results. Inarguably, vitamin D deficiency is a very real risk for vegans, with the potential to adversely affect bone density.

There are a multiplicity of other factors, such as digestion, forms of nutrients, and biochemical individuality, which are not addressed in this paper. Additionally, there are multiplicities of nutrients pertinent to adequate bone development and maintenance, including vitamin B-12, omega-3 fatty acids, vitamin K, magnesium, potassium, and phytonutrients, such as isoflavones.^{38,39} As said previously, this is a complex subject and there is need for more integrative studies to bring these factors into the vegan diet question.

As far as protein is concerned, a properly planned vegan diet has the potential to provide sufficient plant-based protein to support healthy bones, which appears sufficient to support a healthy bone matrix. Although the role of calcium in a strong skeletal system is undisputed, and vegan diets are generally lower in calcium than those that include dairy products, the increased intake of vegetables and fruits in a vegan diet may be somewhat protective against bone loss, thus compensating for lower calcium intake.⁴⁰ There are few studies that report on vitamin D in vegans, but it does appear that vegans are at risk for vitamin D deficiency or insufficiency, thus increasing their risk of osteoporosis. However, some literature has shown that despite this deficiency, bone density was maintained.

There is need for continued population and epidemiological studies regarding dietary patterns and whole food intake to understand this issue more fully. Further, more specific definitions of diet types would aid in identifying the risk/benefits of various diet patterns. In the meantime, it appears that the answer to the question posed herein seems to be “yes.” Those who choose a vegan diet can plan their food and lifestyles to ensure adequate bone nutrition, but some may need to supplement their diet as well.

Conclusion

Vegan diets, although high in many important nutrients, have the potential to be deficient in protein, calcium, and vitamin D. Despite these risks, some studies have demonstrated that it is possible for vegans to maintain bone density at least equal to that of omnivores. In conclusion, it does appear that those individuals who choose a vegan diet may have healthy bones, with prudent planning of their dietary habits. More research is needed in order to understand more fully the impact of veganism on bone health.

References

1. Liu Y, Liu J. Herbal medicines for treating osteoporosis (protocol). *The Cochrane Library*. 2008(4):1-8.
2. NIH Consensus Development Panel on Osteoporosis Prevention, Diagnosis, and Therapy. Osteoporosis prevention, diagnosis, and therapy. *JAMA*. 2001 Feb14; 285(6): 785-95.
3. Rice B, Quann E, Miller G. Meeting and exceeding dairy recommendations: Effects of dairy consumption on nutrient intakes and risk of chronic disease. *Nutr Rev*. 2013; 71(4): 209-223.
4. Abelow B, Holford T, Insogna K. Cross-cultural association between dietary animal protein and hip fracture: A hypothesis. *Calcif Tissue Int*. 1992; 50:14-18.
5. Lanou A. Should dairy be recommended as part of a healthy vegetarian diet? Counterpoint. *Am J Clin Nutr* 2009; 89(Suppl): 16388-42S.
6. Michaelsson K, Wolk A, Langenskiold S, Basu S, Warensjo Lemming E, Melhus H, et al. Milk intake and risk of mortality and fractures in women and men: Cohort studies. *BMJ*. 2014 Oct 28;349:g6015.
7. Le LT, Sabate J. Beyond meatless, the health effects of vegan diets: Findings from the Adventist cohorts. *Nutr*. 2014 May 27; 6(6): 2131-47.
8. Smith AM. Veganism and osteoporosis: A review of the current literature. *Int J Nurs Pract*. 2006 Oct; 12(5): 302-6.
9. Craig WJ. Nutrition concerns and health effects of vegetarian diets. *Nutr Clin Pract*. 2010 Dec; 25(6): 613-20.
10. Key TJ, Appleby PN, Rosell MS. Health effects of vegetarian and vegan diets. *Proc Nutr Soc*. 2006 Feb; 65(1): 35-41.
11. New SA. Do vegetarians have a normal bone mass? *Osteoporos Int*. 2004 Sep; 15(9): 679-88.
12. Lanham-New SA. Importance of calcium, vitamin D and vitamin K for osteoporosis prevention and treatment. *Proc of the Nutr Soc*. 2008; 67: 163-176.
13. Karaaslan F, Mutlu M, Mermerkaya MU, Karaoglu S, Sacmaci S, Kartal S. Comparison of bone tissue trace-element concentrations and mineral density in osteoporotic femoral neck fractures and osteoarthritis. *Clin Interv Aging*. 2014 Aug18; 9:1375-82.

14. Alrabadi JI. The effect of lifestyle food on chronic diseases: a comparison between vegetarians and non-vegetarians in Jordan. *Glob J Health Sci*. 2012 Nov 4; 5(1): 65-9.
15. Appleby P, Roddam A, Allen N, Key T. Comparative fracture risk in vegetarians and non-vegetarians in EPIC-Oxford. *Eur J Clin Nutr*. 2007 Dec; 61(12): 1400-6.
16. Wang YF, Chiu JS, Chuang MH, Chiu JE, Lin CL. Bone mineral density of vegetarian and non-vegetarian adults in Taiwan. *Asia Pac J Clin Nutr*. 2008; 17(1): 101-6.
17. Ho-Pham LT, Vu BQ, Lai TQ, Nguyen ND, Nguyen TV. Vegetarianism, bone loss, fracture and vitamin D: A longitudinal study in Asian vegans and non-vegans. *Eur J Clin Nutr*. 2012 Jan; 66(1): 75-82.
18. Haddad E, Sabate J, Whitten C. Vegetarian food guide pyramid: a conceptual framework. *Am J Clin Nutr*. 1999; 70(Suppl): 615S-9S.
19. Sabate J. The contribution of vegetarian diets to health and disease: A paradigm shift? *Am J Clin Nutr*. 2003; 78(suppl): 502S-7S.
20. Smith AM. Veganism and osteoporosis: A review of the current literature. *Int J Nurs Pract*. 2006 Oct;12(5):302-6.
21. Weaver CM, Plawecki KL. Dietary calcium: Adequacy of a vegetarian diet. *Am J Clin Nutr*. 1994 May;59(5 Suppl):1238S-41S).
22. Sellmeyer DE, Stone XL, Sebastian A, Cummings SR. A high ratio of dietary animal to vegetable protein increases the rate of bone loss and the risk of fracture in postmenopausal women: Study of osteoporotic fractures research group. *Am J Clin Nutr*. 2001 Jan; 73(10):118-22.
23. Mangano KM, Sabni S, Kerstetter JE. Dietary protein is beneficial to bone health under conditions of adequate calcium intake: An update on clinical research. *Curr Opin Clin Nutr Metab Care*. 2014 Jan;17(1): 69-74.
24. Chen YM, Ho SC, Woo JL. Greater fruit and vegetable intake is associated with increased bone mass among postmenopausal Chinese women. *Br J Nutr*. 2006 Oct; 96(4): 745-51.
25. New SA. Nutrition society medal lecture. The role of the skeleton in acid-base homeostasis. *Proc Nutr Soc*. 2002 May; 61(2):151-64.
26. Thorpe DL, Knutsen SF, Beeson WL, Rajaram S, Fraser GE. Effects of meat consumption and vegetarian diet on risk of wrist fracture over 25 years in a cohort of peri- and postmenopausal women. *Public Health Nutr*. 2008 Jun; 11(6): 564-72.

27. Bonjour JP, Kraenzlin M, Levasseur R, Warren M, Whiting S. Dairy in adulthood: From foods to nutrient interactions on bone and skeletal muscle health. *J Am Coll Nutr*. 2013; 32(4): 251-63.
28. Darling AL, Millward DJ, Torgerson DJ, Hewitt CE, Lanham-New SA. Dietary protein and bone health: A systematic review and meta-analysis. *Am J Clin Nutr*. 2009 Dec; 90(6): 1674-92.
29. Pedersen AN, Cederholm T. Health effects of protein intake in healthy elderly populations: A systematic literature review. *Food Nutr Res*. 2014 Feb 11; 58:10.3402fnr.v58.23364. eCollection 2014.
30. Fenton TR, Tough SC, Lyon AW, Eliasziw M, Hanley DA. Causal assessment of dietary acid load and bone disease: A systematic review & meta-analysis applying Hill's epidemiologic criteria for causality. *Nutr J*. 2011 Apr 30; 10:41.2891-10-41.
31. Fenton TR, Lyon AW, Eliasziw M, Tough SC, Hanley DA. Meta-analysis of the effect of the acid-ash hypothesis of osteoporosis on calcium balance. *J Bone Miner Res*. 2009 Nov; 24(11): 1835-40.
32. Heaney RP, Layman DK. Amount and type of protein influences bone health. *Am J Clin Nutr*. 2008 May; 87(5): 1567S-70S.
33. New S. Intake of fruit and vegetables: Implications for bone health. *Proc of the Nutr Soc*. 2003; 62: 889-899.
34. Bolland MJ, Grey A, Avenell A, Gamble GD, Reid IR. Calcium supplements with or without vitamin D and risk of cardiovascular events: Re-analysis of the Women's Health Initiative limited access dataset and meta-analysis. *BMJ*. 2011 Apr 19; 342: d2040.
35. Ho-Pham L, Nguyen P, Le T, Doan D. Veganism, bone mineral density, and body composition: A study in Buddhist nuns. *Osteoporos Int*. 2009; 20: 2087-2093.
36. Frassetto L, Todd K, Morris R, Sebastian A. Worldwide incidence of hip fracture in elderly women. *The Journals of Gerontology Series A: Biological and Medical Sciences*. 2000; 55: M585-M592.
37. Calvo MS, Babu US, Garthoff LH, Woods TO, Dreher M, Hill G, et al. Vitamin D2 from light-exposed edible mushrooms is safe, bioavailable and effectively supports bone growth in rats. *Osteoporos Int*. 2013 Jan; 24(1); 197-207.
38. Mangels AR. Bone nutrients for vegetarians. *Am J Clin Nutr*. 2014 Jun 4: 100(Supplement); 469S-75S.

39. Tucker KL. Vegetarian diets and bone status. *Am J Clin Nutr.* 2014 Jun 4: 100(Supplement 1); 329S-35S.
40. Fraser GF. Vegetarian diets: What do we know of their effects on common chronic diseases? *Am j Clin Nutr.* 2009; 89(Suppl): 16-7S-12S.