How to Monitor and Advise Vegans to Ensure Adequate Nutrient Intake

Heather Fields, MD; Barbara Ruddy, MD; Mark R. Wallace, MD; Amit Shah, MD; Denise Millstine, MD; and Lisa Marks, MLS

From Mayo Clinic in Scottsdale, Arizona.

Financial Disclosures: None reported.

Support: None reported.

Address correspondence to Heather Fields, MD, Mayo Clinic, Community Internal Medicine, 13400 E Shea Blvd, Scottsdale, AZ 85259-5452.

E-mail: fields.heather@mayo.edu

Submitted April 24, 2015; accepted June 12, 2015.

According to a 2012 report, 2% of the US population follows a vegan diet, which is a strict plant-based diet that excludes all animal-derived foods.[1] Increasingly, people are choosing to follow this diet for ethical, environmental, religious, and health concerns.[2] The increase in patients following a vegan diet can lead to requests for provider advice about the safety of this dietary pattern. Several studies have demonstrated health benefits of plant-based diets, including improvements in ischemic heart disease mortality, as well as decreases in hypertension, hyperlipidemia, obesity, type 2 diabetes mellitus, and cancer incidence.[3-13] Despite these benefits, could vegans be at risk for deficiency of essential nutrients? The present article concisely summarizes the recent literature examining potential negative consequences of a vegan diet and assists clinicians in their conversations with patients.[8,14]

Clinical Question: Do nutritional risks exist for vegans?

Evidence: Vegans may be at increased risk for deficiencies in vitamin B_{12}, iron, calcium, vitamin D, omega-3 fatty acids, and protein; however, implications are not always clear.

Recommendation: Physicians should encourage vegan patients to vary their sources of nutrients. Periodic monitoring of serum nutrient levels is also recommended.

The Evidence

In December 2014, we performed an independent literature review of the PubMed, EMBASE, and Medline databases from 2004 to the present. The following search terms were used: *vegan*, *risk,*, *safety*, *vitamin B_{12}*, *protein*, *amino acids*, *iron*, *calcium*, *omega-3 fatty acids*, *eicosapentaenoic acid* (EPA), and *docosahexaenoic acid* (DHA). We included all prospective cohort, cross-sectional, and review articles on the proposed risks associated with vegan diets. Non-English studies and studies regarding the health benefits of a vegan diet and effects in pregnancy and breastfeeding were excluded. We identified 167 titles and abstracts and reviewed relevant full texts and pertinent references. The *Table* identifies nutrients of concern and sources of those nutrients for vegans, and the *Figure* provides suggested actions for primary care physicians.

Vitamin B_{12}

Plant foods contain a negligible amount of vitamin B_{12}; thus, vegans have difficulty meeting the recommended daily allowance (2.4 µg) and maintaining adequate serum concentrations of B_{12}. In a cross-sectional study of 689 men, 121 of 232 vegans (52%) were B_{12} deficient (<118 pmol/L), whereas only 1 of 226 omnivores (0%) was B_{12} deficient.[15] A prospective study of 20 omnivores who adopted a vegan diet over 5 years showed that B_{12} levels were only maintained in the patients who consumed B_{12}-fortified products.[16]

Vitamin B_{12} deficiency can cause cognitive disorders, neuropathies, weakness, and macrocytic anemia, which can result in fatigue and low energy.[17] Deficiency also affects digestion and absorption of nutrients and metabolism of serotonin and melatonin.[17] Vegetarians have a lower risk of death from ischemic heart disease[5,18]; however, low B_{12} levels have been associated with worsening of some cardiovascular markers. A cross-sectional study of 154 vegans revealed an elevated homocystine level in 66% of participants, of whom 93% also had low B_{12} levels (<250 pmol/L).[19] A 2014 review[6] identified elevated homocysteine level, impaired brachial flow-mediated endothelial dilation, and increased carotid intimal medial thickness in patients with low B_{12} levels. These effects were improved with B_{12} supplementation.[6]

Considering the frequency of B_{12} deficiency in vegans, providers should advise vegans to take supplemental B_{12} or eat B_{12}-fortified foods. To ensure adequate intake, periodic monitoring of B_{12} levels should be considered.

Iron

Iron deficiency is one of the most common nutritional deficiencies worldwide.[20] Although the overall iron intake in vegans is surprisingly greater than that in omnivores, levels of ferritin, which stores iron, are often lower in vegans.[14,21,22] Absorption and storage is affected by the bioavailability of nonheme iron (plant sources) being less than that of heme iron (animal sources).[14,20] The vegan diet contains nutrients that both enhance and inhibit iron absorption, such as organic acids and phytates, respectively, leading to variable iron levels.[4,20] Iron deficiency is more prevalent in young vegan women compared with older vegan women[20] and men and women following omnivore diets.[21]

Periodic assessments of anemia and iron status should be considered for all vegans but especially for vegan children and women of childbearing age. Health care professionals should encourage patients with documented low ferritin levels to take a bioavailable supplement with absorption-enhancing foods.

Calcium and Vitamin D

Multiple studies have documented lower intake of calcium and vitamin D in vegans,[20,23] yet the implications of a vegan diet in bone health, particularly bone mineral density (BMD), have been varied. Several investigations have demonstrated lower BMD in vegans compared with nonvegans,[23-26] whereas 1 study showed no difference.[27]

Data on fracture incidence are also mixed. In 1 study, fracture incidence was 30% higher in vegans than in nonvegans, though participants with a minimum daily calcium intake of 525 mg had no increase in fractures.[28] A prospective longitudinal study of Asian women found no statistically significant difference in fracture incidence between vegans and nonvegans.[29]

Gastrointestinal calcium absorption increases when dietary calcium intake is low, and lower animal protein intake decreases renal calcium excretion. Thus, the skeletal effects of a vegan diet might be attenuated. The higher intake of vitamin K and phytoestrogens and increased alkalinity of vegan diets are also thought to improve BMD.

Many factors affect bone health. Osteoporosis, fracture risk, and vitamin D deficiency are not unique to the vegan diet; nevertheless, health care professionals should advise vegans to consume at least 525 mg of calcium and 15 µg of vitamin D per day. Periodic monitoring of BMD could be considered, but recent evidence is not conclusive.

Table.
Vegan Sources of Nutrients

Nutrient	Vegan Sources
Vitamin B_{12}	Cereal, fortified soy and rice milk, meat analogs, nutritional yeast, supplements
Calcium	Blackstrap molasses, collard greens, fortified plant milks and juices
Vitamin D	Fortified plant milk; ultraviolet B–exposed mushrooms
Omega-3 fatty acids (EPA, DHA)	Algae (EPA and DHA), chia, flaxseed, walnuts
Iron	Spinach, collard greens, lentils, soybeans, tofu
Essential amino acids	Soy, quinoa, buckwheat, hempseed, chia, legumes

Abbreviations: DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid.

Omega-3 Fatty Acids (EPA and DHA)

Two essential fatty acids must be acquired in the diet because the human body cannot make them: linoleic acid (LA) and α-linolenic acid (ALA). Linoleic acid is the main component of most vegetable-based oils; consequently, the vegan diet need only include vegetable fat to avoid deficiency. α-Linolenic acid is found in many vegan foods: soy, soybean oil, canola (rapeseed) oil, walnuts, and flaxseeds. Two additional fatty acids, EPA and DHA, are deficient in the vegan diet. Vegans do not ingest EPA or DHA unless they consume large amounts of seaweed, so they are dependent on synthesis of these fatty acids from ALA. The health effects of lower levels of EPA and DHA remain

Ask all patients about dietary restrictions and ask vegans about symptoms of associated deficiencies (eg, fatigue, cognitive dysfunction, neuropathies, fractures).
Monitor vegan patients on an annual basis for serum levels of vitamin B_{12}, calcium, vitamin D, and iron.
Advise vegan patients to consume adequately fortified foods with RDAs of vitamin B_{12}, iron, calcium, vitamin D, and varied sources of protein.
Vegans can consider supplementation with algae for EPA and DHA if desired.
For vegans, consider recommending a consultation with a registered dietician.

Figure.
Suggested actions for primary care physicians.

a concern. Both play major roles in metabolism, including EPA's effect on platelet aggregation (via thromboxane) and inflammation (via leukotrienes) and DHA's effect on brain and visual functioning.

A review of the literature reveals that these worries have not been substantiated. Studies of children brought up with a vegan diet have not shown problems in visual or cognitive development.[30] A study of vegan men showed no effect on IQ (intelligence quotient) compared with nonvegan men, and a study of Seventh Day Adventist vegetarians showed no increase in dementia.[31,32]

There is no convincing evidence that vegans have health consequences from lower levels of omega-3 fatty acids. Concerned vegans can increase their consumption of foods containing ALA, and health care professionals can inform patients that plant-based DHA supplements (such as those derived from algae) are available.

Protein

Concerns about protein deficiency in vegans abound, yet little is known about the likelihood of vegans ingesting less than the minimum recommended intake. The accuracy of reporting protein intake is complicated, as many foods are sources of protein. Modern diets, including the vegan diet, tend to include higher protein intake than the Institute of Medicine's recommended daily intake for adult women (46 g) and men (56 g).[33] In a study of British vegans, the total reported protein intake was lower compared with the national average for men (65 vs 87 g/d) and women (47 vs 66 g/d)[34] but still met the Institute of Medicine's recommendations. A prospective trial of omnivores placed on a vegan diet for 18 weeks showed a decline of only 1.1% in total protein calories.[35]

Despite these reports, protein intake remains a concern. Essential amino acids must be ingested because the body is incapable of manufacturing them independently. Plant sources are commonly believed to be incomplete sources of protein and to lack at least 1 essential amino acid. A specific food source may have low levels of a specific amino acid, but none is completely absent.[36] No evidence has shown that vegans become deficient in specific amino acids.

To ensure appropriate protein levels, providers should advise vegans that they will achieve adequate essential amino acid and protein intake by varying the plant sources that comprise their diet.[37]

Conclusion

A vegan diet has many health benefits but is not without risk of dietary deficiencies. Health care professionals should ask patients about their dietary practices and assess for possible nutrient deficiencies through physical examination, periodic serum monitoring (including complete blood cell count, vitamin B_{12}, iron, calcium, and vitamin D), and perhaps BMD monitoring. (doi:10.7556/jaoa.2016.022)

References

1. Newport F. In U.S., 5% consider themselves vegetarians. Gallup website. 2012; http://www.gallup.com/poll/156215/consider-themselves-vegetarians.aspx. Posted July 26, 2012. Accessed September 27, 2014.
2. Crawford E. Vegan is going mainstream, trend data suggests. Food Navigator-USA website. http://www.foodnavigator-usa.com/Markets/Vegan-is-going-mainstream-trend-data-suggests. Posted March 17, 2015. Accessed December 18, 2015.
3. Craig WJ, Mangels AR; American Dietetic Association. Position of the American Dietetic Association: vegetarian diets. *J Am Diet Assoc*. 2009;109(7):1266-1282.
4. Clarys P, Deliens T, Huybrechts I, et al. Comparison of nutritional quality of the vegan, vegetarian, semi-vegetarian, pesco-vegetarian and omnivorous diet. *Nutrients*. 2014;6(3):1318-1332. doi:10.3390/nu6031318.

5. Huang T, Yang B, Zheng J, Li G, Wahlqvist ML, Li D. Cardiovascular disease mortality and cancer incidence in vegetarians: a meta-analysis and systematic review. *Ann Nutr Metab.* 2012;60(4):233-240. doi:10.1159/000337301.

6. Woo KS, Kwok TCY, Celermajer DS. Vegan diet, subnormal vitamin B-12 status and cardiovascular health. *Nutrients.* 2014;6(8):3259-3273. doi:10.3390/nu6083259.

7. Le LT, Sabaté J. Beyond meatless, the health effects of vegan diets: findings from the Adventist cohorts. *Nutrients.* 2014;6(6):2131-2147. doi:10.3390/nu6062131.

8. Key TJ, Appleby PN, Rosell MS. Health effects of vegetarian and vegan diets. *Proc Nutr Soc.* 2006;65(1):35-41.

9. Barnard ND, Cohen J, Jenkins DJ, et al. A low-fat vegan diet and a conventional diabetes diet in the treatment of type 2 diabetes: a randomized, controlled, 74-wk clinical trial. *Am J Clin Nutr.* 2009;89(5):1588S-1596S. doi:10.3945/ajcn.2009.26736H.

10. Esselstyn CB Jr, Gendy G, Doyle J, Golubic M, Roizen MF. A way to reverse CAD? *J Fam Pract.* 2014;63(7):356-364b.

11. Ornish D, Brown SE, Scherwitz LW, et al. Can lifestyle changes reverse coronary heart disease? The Lifestyle Heart Trial. *Lancet.* 1990;336(8708):129-133.

12. Tonstad S, Butler T, Yan R, Fraser GE. Type of vegetarian diet, body weight, and prevalence of type 2 diabetes. *Diabetes Care.* 2009;32(5):791-796. doi:10.2337/dc08-1886.

13. Yokoyama Y, Barnard ND, Levin SM, Watanabe M. Vegetarian diets and glycemic control in diabetes: a systematic review and meta-analysis. *Cardiovasc Diagn Ther.* 2014;4(5):373-382. doi:10.3978/j.issn.2223-3652.2014.10.04.

14. Craig WJ. Nutrition concerns and health effects of vegetarian diets. *Nutr Clin Pract.* 2010;25(6):613-620. doi:10.1177/0884533610385707.

15. Gilsing AM, Crowe FL, Lloyd-Wright Z, et al. Serum concentrations of vitamin B12 and folate in British male omnivores, vegetarians and vegans: results from a cross-sectional analysis of the EPIC-Oxford cohort study. *Eur J Clin Nutr.* 2010;64(9):933-939. doi:10.1038/ejcn.2010.142.

16. Madry E, Lisowska A, Grebowiec P, Walkowiak J. The impact of vegan diet on B-12 status in healthy omnivores: five-year prospective study. *Acta Sci Pol Technol Aliment.* 2012;11(2):209-212.

17. Sridevy, Baby P. Overcoming vitamin B12 deficiency in vegan diet. *Nitte Univ J Health Sci.* 2014;4(1):104-105.

18. Key TJ, Fraser GE, Thorogood M, et al. Mortality in vegetarians and non-vegetarians: a collaborative analysis of 8300 deaths among 76,000 men and women in five prospective studies. *Public Health Nutr.* 1998;1(1):33-41.

19. Waldmann A, Koschizke JW, Leitzmann C, Hahn A. German vegan study: diet, life-style factors, and cardiovascular risk profile. *Ann Nutr Metab.* 2005;49(6):366-372.

20. Waldmann A, Koschizke JW, Leitzmann C, Hahn A. Dietary iron intake and iron status of German female vegans: results of the German vegan study. *Ann Nutr Metab.* 2004;48(2):103-108.

21. Kajanachumpol S, Atamasirikul K, Viroonudomphol D. Iron status among Thai vegans. *J Med Technol Assoc Thailand.* 2012;40(1).

22. Craig WJ. Health effects of vegan diets. *Am J Clin Nutr.* 2009;89(5):1627S-1633S. doi:10.3945/ajcn.2009.26736N.

23. Parsons TJ, van Dusseldorp M, van der Vliet M, van de Werken K, Schaafsma G, van Staveren WA. Reduced bone mass in Dutch adolescents fed a macrobiotic diet in early life. *J Bone Miner Res.* 1997;12(9):1486-1494.

24. Chiu JF, Lan SJ, Yang CY, et al. Long-term vegetarian diet and bone mineral density in postmenopausal Taiwanese women. *Calcif Tissue Int.* 1997;60(3):245-249.

25. Lau EM, Kwok T, Woo J, Ho SC. Bone mineral density in Chinese elderly female vegetarians, vegans, lacto-vegetarians and omnivores. *Eur J Clin Nutr.* 1998;52(1):60-64.

26. Outila TA, Kärkkäinen MU, Seppänen RH, Lamberg-Allardt CJ. Dietary intake of vitamin D in premenopausal, healthy vegans was insufficient to maintain concentrations of serum 25-hydroxyvitamin D and intact parathyroid hormone within normal ranges during the winter in Finland. *J Am Diet Assoc.* 2000;100(4):434-441.

27. Ho-Pham LT, Nguyen PL, Le TT, et al. Veganism, bone mineral density, and body composition: a study in Buddhist nuns. *Osteoporos Int.* 2009;20(12):2087-2093. doi:10.1007/s00198-009-0916-z.

28. Appleby P, Roddam A, Allen N, Key T. Comparative fracture risk in vegetarians and nonvegetarians in EPIC-Oxford. *Eur J Clin Nutr.* 2007;61(12):1400-1406.

29. 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;66(1):75-82. doi:10.1038/ejcn.2011.131.

30. Sanders TA, Reddy S. Vegetarian diets and children. *Am J Clin Nutr.* 1994;59(5 suppl):1176S-1181S.

31. Giem P, Beeson WL, Fraser GE. The incidence of dementia and intake of animal products: preliminary findings from the Adventist Health Study. *Neuroepidemiology.* 1993;12(1):28-36.

32. Lloyd-Wright Z. *The Nutritional Status of Vegan Men in the United Kingdom with Particular Reference to Vitamin B12* [doctoral thesis]. London, UK; University of London; 2005.

33. Institute of Medicine. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acid, Cholesterol, Protein, and Amino Acids*. Washington, DC: The National Academies Press; 2005.

34. Draper A, Lewis J, Malhotra N, Wheeler E. The energy and nutrient intakes of different types of vegetarian: a case for supplements? *Br J Nutr.* 1993;69(1):3-19.

35. Mishra S, Xu J, Agarwal U, Gonzales J, Levin S, Barnard ND. A multicenter randomized controlled trial of a plant-based nutrition program to reduce body weight and cardiovascular risk in the corporate setting: the GEICO study. *Eur J Clin Nutr.* 2013;67(7):718-724. doi:10.1038/ejcn.2013.92.

36. Young VR, Pellett PL. Plant proteins in relation to human protein and amino acid nutrition. *Am J Clin Nutr.* 1994;59(suppl):1203S-1212S.

37. Phillips F. Vegetarian nutrition. *Nutr Bull.* 2005;30(2):132-167. doi:10.1111/j.1467-3010.2005.00467.x.