Position of the Academy of Nutrition and Dietetics: Vegetarian Diets

ABSTRACT

It is the position of the Academy of Nutrition and Dietetics that appropriately planned vegetarian, including vegan, diets are healthful, nutritionally adequate, and may provide health benefits for the prevention and treatment of certain diseases. These diets are appropriate for all stages of the life cycle, including pregnancy, lactation, infancy, childhood, adolescence, older adulthood, and for athletes. Plant-based diets are more environmentally sustainable than diets rich in animal products because they use fewer natural resources and are associated with much less environmental damage. Vegetarians and vegans are at reduced risk of certain health conditions, including ischemic heart disease, type 2 diabetes, hypertension, certain types of cancer, and obesity. Low intake of saturated fat and high intakes of vegetables, fruits, whole grains, legumes, soy products, nuts, and seeds (all rich in fiber and phytochemicals) are characteristics of vegetarian and vegan diets that produce lower total and low-density lipoprotein cholesterol levels and better serum glucose control. These factors contribute to reduction of chronic disease. Vegans need reliable sources of vitamin B-12, such as fortified foods or supplements.

J Acad Nutr Diet. 2016;116:1970-1980.

POSITION STATEMENT

It is the position of the Academy of Nutrition and Dietetics that appropriately planned vegetarian, including vegan, diets are healthful, nutritionally adequate, and may provide health benefits in the prevention and treatment of certain diseases. These diets are appropriate for all stages of the life cycle, including pregnancy, lactation, infancy, childhood, adolescence, older adulthood, and for athletes. Plant-based diets are more environmentally sustainable than diets rich in animal products because they use fewer natural resources and are associated with much less environmental damage.

VEGETARIAN AND VEGAN dietary patterns can be quite diverse because of the variety of food choices available and the different factors that motivate people to adopt such patterns. People choose to adopt a vegetarian diet for many reasons, such as compassion toward animals, a desire to better protect the environment, to lower their risk of chronic diseases, or to therapeutically manage those diseases. A well-planned vegetarian diet containing vegetables, fruits, whole grains, legumes, nuts, and seeds can provide adequate nutrition. Vegetarian diets are devoid of flesh foods (such as meat, poultry, wild game, seafood, and their products). The most commonly followed vegetarian diets are shown in Figure 1. The adoption of a vegetarian diet may cause a reduced intake of certain nutrients; however, deficiencies can be readily avoided by appropriate planning.

2212-2672/Copyright © 2016 by the Academy of Nutrition and Dietetics.
http://dx.doi.org/10.1016/j.jand.2016.09.025

VEGETARIAN DIETS IN PERSPECTIVE

Trends among Vegetarians

According to a nationwide poll in 2016, approximately 3.3% of American adults are vegetarian or vegan (never eat meat, poultry, or fish), and about 46% of vegetarians are vegan.[1] The same poll revealed that 6% of young adults (18 to 34 years) are vegetarian or vegan, while only 2% of those 65 years or older are vegetarian. Sales of alternative meat products reached $553 million in 2012, an 8% increase in 2 years. It was observed that 36% of survey responders sought vegan meat alternatives, largely from among the 18- to 44-year-old age group.[1,2] While whole plant foods serve best as dietary staples, some processed and fortified foods, such as nondairy beverages, meat analogs, and breakfast cereals, can contribute substantially to the nutrient intake of vegetarians.

Plant-based diets, including vegetarian and vegan diets, are becoming well accepted, as further evidenced by many nonprofit and government institutions highlighting this dietary choice. The American Institute for Cancer Research encourages a plant-based diet, suggesting Americans consume two-thirds of their dietary intake from vegetables, fruits, whole grains, and beans.[3] In the 2015-2020 Dietary Guidelines for Americans, vegetarian diets are recommended as one of three healthful dietary patterns, and meal plans are provided for those following lacto-ovo-vegetarian and vegan diets.[4] The National School Lunch Program, while not requiring vegetarian options per se, requires schools to increase availability of fruits, vegetables, and whole grains in current meal patterns in the school menu.

Those following a vegetarian diet now have technological support. To date, while no online nutrition food tracker exists strictly for vegetarian diets, some allow clients to select vegetarian and vegan plans. These applications for mobile devices allow vegetarians to discover nutritional needs, track intake, and locate restaurants and markets where vegan foods are available. The online tracking tool at www.SuperTracker.usda.gov is a part of the US Department of Agriculture Choose My Plate program.[5]

NUTRITION CONSIDERATIONS FOR VEGETARIANS

Protein

Vegetarian, including vegan, diets typically meet or exceed recommended

Type of diet	Nature of diet (all are devoid of flesh foods)
Vegetarian	May or may not include egg or dairy products.
Lacto-ovo-vegetarian	Includes eggs and dairy products.
Lacto-vegetarian	Includes dairy products, but not egg products.
Ovo-vegetarian	Includes eggs and egg products, but no dairy.
Vegan	Excludes eggs and dairy products, and may exclude honey.
Raw vegan	Based on vegetables, fruit, nuts and seeds, legumes, and sprouted grains. The amount of uncooked food varies from 75% to 100%.

Figure 1. Types of vegetarian diets.

protein intakes, when caloric intakes are adequate.[6-8] The terms *complete* and *incomplete* are misleading in relation to plant protein. Protein from a variety of plant foods, eaten during the course of a day, supplies enough of all indispensable (essential) amino acids when caloric requirements are met.[7] The regular use of legumes and soy products will ensure an adequate protein intake for the vegetarian, as well as providing other essential nutrients.[9] Fruitarian diets are normally low in protein and other nutrients. Protein needs at all ages, including those for athletes, are well achieved by balanced vegetarian diets.[7,8]

n-3 Fatty Acids

While α-linolenic acid (ALA) intakes of vegetarians and vegans are similar to those of nonvegetarians, dietary intakes of the long-chain n-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are lower in vegetarians and typically absent in vegans.[10,11] Compared with nonvegetarians, blood and tissue levels of EPA and DHA can be significantly lower.[10,11]

The clinical relevance of reduced EPA and DHA status among vegetarians and vegans is unknown.[11,12] Long-chain n-3 fatty acids are important for the development and maintenance of the brain, retina, and cell membranes and favorably impact pregnancy outcomes and risk for cardiovascular disease (CVD) and other chronic diseases.[6,13,14] Yet, vegetarian and vegan children do not appear to experience impairment in visual or mental development, and vegetarian and vegan adults experience reduced risk for CVD.[10,11,15]

ALA is endogenously converted to EPA and DHA, but the process is somewhat inefficient and is affected by sex, dietary composition, health status, and age. High intakes of linoleic acid (LA) may suppress ALA conversion.[11,13] A ratio of LA/ALA not exceeding 4:1 has been suggested for optimal conversion.[7,10,14]

The Dietary Reference Intake for ALA are 1.6 g/day and 1.1 g/day, for men and women, respectively.[4] For vegetarians and vegans, it may be prudent to ensure somewhat higher intakes of ALA.[8,10] The most concentrated plant sources of n-3 fatty acids are seeds (flax, chia, camelina, canola, and hemp), walnuts, and their oils.[8,10] Evidence suggests that n-3 needs of healthy individuals can be met with ALA alone, and that endogenous synthesis of EPA and DHA from ALA is sufficient to keep levels stable over many years.[11,14] Low-dose microalgae–based DHA supplements are available for all vegetarians with increased needs (eg, pregnant or lactating women) or with reduced conversion ability (eg, those with hypertension or diabetes).[10]

Iron

Vegetarians generally consume as much iron as, or slightly more than, omnivores.[16] Despite having similar iron intakes,[17] the iron stores of vegetarians are typically below those of nonvegetarians. Lower serum ferritin levels may be an advantage because elevated serum ferritin levels have independently been associated with the risk of developing metabolic syndrome.[18]

Concerns about the iron status of vegetarians have led to questions of bioavailability of non-heme iron from plant foods. Non-heme iron absorption depends upon physiological need and is regulated in part by iron stores. Its absorption can vary greatly, depending upon both the meal composition and the iron status of the individual. Bioavailability of non-heme iron is impacted by the ratio of inhibitors, such as phytates and polyphenolics, and enhancers, such as vitamin C, citric acid, and other organic acids.[19]

In a recent review, non-heme iron absorption was seen to vary from 1% to 23%, depending upon iron status and dietary enhancers and inhibitors.[20] A newly developed regression equation enables iron absorption to be predicted from serum ferritin levels and dietary modifiers. Diet had a greater effect on iron absorption when serum ferritin levels were low.[20] Nonheme iron absorption can be as much as 10 times greater in iron-deficient individuals compared with iron-replete individuals.

The Dietary Reference Intake assigned to iron for vegetarians in 2001 was 80% more than that for nonvegetarians. This derives from the assumption that the bioavailability of iron from a vegetarian diet is 10%, whereas that from a nonvegetarian diet is 18%.[21] These assumptions were based on very limited data using single-meal absorption studies involving meals that were atypical of what most vegetarians consume in Western countries.

We now know that individuals can adapt and absorb non-heme iron more effectively.[22] The magnitude of the effect of enhancers and inhibitors of iron absorption can diminish with time.[23] Individuals are able to adapt to low intakes of iron over time and can reduce iron losses.[24] In one study, total iron absorption significantly increased by almost 40% after 10 weeks of consuming the low-bioavailability diet.[22]

Individuals with low iron status can substantially increase their iron absorption from diets with moderate to high iron bioavailability. The absorption process appears to adapt effectively in the case of Western vegetarians because their hemoglobin values and most other measures of iron status are similar to those values seen in nonvegetarians.[7]

Zinc

Compared with nonvegetarian control groups, studies show adult vegetarians have dietary zinc intakes that are similar or somewhat lower, and serum zinc concentrations that are lower but within the normal range.[7,25] There do not appear to be any adverse health consequences in adult vegetarians that are attributable to a lower zinc status, possibly due to homeostatic mechanisms that allow adults to adapt to a vegetarian diet. Overt zinc deficiency is not evident in Western vegetarians. For the most at-risk members of the population (older adults, children, and pregnant and lactating women), there is insufficient evidence to determine whether zinc status is lower in vegetarians compared with nonvegetarians.[25] Zinc sources for the vegetarian include soy products, legumes, grains, cheese, seeds, and nuts. Food preparation techniques, such as soaking and sprouting beans, grains, nuts, and seeds, as well as leavening bread, can reduce binding of zinc by phytic acid and increase zinc bioavailability.[26] Organic acids, such as citric acid, also can enhance zinc absorption to some extent.[26]

Iodine

Because plant-based diets can be low in iodine, vegans who do not consume key vegan sources of iodine, such as iodized salt or sea vegetables, may be at risk for iodine deficiency.[7,27] The iodine content of sea vegetables varies widely and some may contain substantial amounts of iodine.[28] Intakes should not exceed the Tolerable Upper Intake Level of 1,100 μg for adults.[29] Vegan women of child-bearing age should supplement with 150 μg/day iodine.[27,29] Sea salt, kosher salt, and salty seasonings, such as tamari, are generally not iodized,[7] and iodized salt is not used in processed foods. Dairy products may contain iodine, although amounts can vary considerable.[7] Although foods such as soybeans, cruciferous vegetables, and sweet potatoes contain natural goitrogens, these foods have not been associated with thyroid insufficiency in healthy people, provided that iodine intake is adequate.[7,8,29,30]

Calcium

Intakes of lacto-ovo-vegetarians typically meet or exceed calcium recommendations, while calcium intakes of vegans vary widely and sometimes fall below recommendations.[7] Bioavailability of calcium from plant foods, which is related to oxalate content of foods and, to a lesser degree, phytate and fiber, is an important consideration. Fractional absorption from high-oxalate vegetables, such as spinach, beet greens, and Swiss chard, may be as low 5%. Thus, these cannot be considered good sources of calcium, despite their high calcium content. In comparison, absorption from low-oxalate vegetables, such as kale, turnip greens, Chinese cabbage, and bok choy, is about 50%.[31] Absorption from calcium-set tofu (made with a calcium salt) and from most fortified plant milks is similar to that from cow's milk, at approximately 30%.[32,33] Other plant foods, such as white beans, almonds, tahini, figs, and oranges, provide moderate amounts of calcium with somewhat lower bioavailability (about 20%). Comparing forms of calcium used for fortification, bioavailability of calcium-citrate-malate can be at least 36%, while others are about 30%.[34] Registered dietitian nutritionists (RDNs) and nutrition and dietetics technicians, registered (NDTRs) can help clients meet calcium needs by encouraging regular consumption of good calcium sources and, when necessary, low-dose calcium supplements.

Vitamin D

Vitamin D status depends on sunlight exposure and intake of vitamin D–fortified foods or supplements.[35] The extent of cutaneous vitamin D production after sunlight exposure is highly variable and is dependent on a number of factors, including the time of day, season, latitude, air pollution, skin pigmentation, sunscreen use, amount of clothing covering the skin, and age.[35,36] Low vitamin D intakes have been reported in some vegetarians and vegans, as well as low plasma or serum 25-hydroxyvitamin D levels, the latter especially when the blood was collected in the winter or spring, and especially in those living at high latitudes.[36] Dietary and supplemental sources of vitamin D are commonly required to meet the needs of this nutrient. Foods that are fortified with vitamin D include cow's milk, some nondairy milks, fruit juices, breakfast cereals, and margarines. Eggs may also provide some vitamin D. Mushrooms treated with ultraviolet light can be significant sources of vitamin D.[36,37] Both vitamin D-2 and vitamin D-3 are used in supplements and to fortify foods. Vitamin D-3 (cholecalciferol) may be of plant or animal origin, while vitamin D-2 (ergocalciferol) is produced from the ultraviolet irradiation of ergosterol from yeast. At low doses, vitamin D-2 and vitamin D-3 appear to be equivalent, but at higher doses vitamin D-2 appears to be less effective than vitamin D-3.[36] If sun exposure and intake of fortified foods are insufficient to meet needs, vitamin D supplements are recommended, especially for the older adults.[35,36,38] Because vitamin D influences a large number of metabolic pathways beyond bone metabolism,[35,38] some experts recommend daily intakes of vitamin D of 1,000 to 2,000 IU, or even more.

Vitamin B-12

Vitamin B-12 is not a component of plant foods.[7,39] Fermented foods (such as tempeh), nori, spirulina, chlorella algae, and unfortified nutritional yeast cannot be relied upon as adequate or practical sources of B-12.[39,40] Vegans must regularly consume reliable sources—meaning B-12–fortified foods or B-12–containing supplements—or they could become deficient, as shown in case studies of vegan infants, children, and adults.[8,39] Most vegetarians should include these reliable B-12 sources because 1 cup of milk and one egg per day only provides about two-thirds of the Recommended Dietary Allowance (RDA).[7,39,40]

Early symptoms of a severe B-12 deficiency are unusual fatigue, tingling in the fingers or toes, poor cognition, poor digestion, and failure to thrive in small children. A subclinical B-12 deficiency results in elevated homocysteine. People with little or no B-12 intake may feel healthy; however, long-term subclinical deficiency can lead to stroke, dementia, and poor bone health.[7,8,41] Laboratory tests to assess vitamin B-12 status include serum methylmalonic acid, serum or plasma B-12, and serum holo-transcobalamin (Holo-TC or Holo-TCII).[8,39,41]

The normal mechanism for B-12 absorption is via the intrinsic factor, which becomes saturated at about half the RDA and requires 4 to 6 hours before further absorption.[40] Hence, fortified foods are best eaten twice during the course of a day. A second absorption mechanism is passive diffusion at a rate of 1%, allowing less-frequent consumption of large supplemental doses. Recommendations based on large doses have been made (eg, 500 to 1,000 μg cyanocobalamin several times per week).[8,39]

The four forms of B-12 are differentiated by their attached groups. Cyanocobalamin is most commonly used in fortified foods and supplements because of its stability. Methylcobalamin and adenosylcobalamin are forms used in the body's enzymatic reactions; these are available in supplement forms that appear to be no more effective than cyanocobalamin and may require higher doses than the RDA. Hydroxocobalamin is the form used effectively for injections.[8,42]

THERAPEUTIC VEGETARIAN DIETS AND CHRONIC DISEASE

Provided that adequate nutrition education is given, a therapeutic vegetarian diet performs as well as omnivorous diets in terms of adherence.[43] As with implementation of any diet, employing a variety of counseling strategies, including motivational interviewing, frequent sessions, cooking demonstrations, and incentives, can improve nutrition-related outcomes when using a vegetarian diet therapeutically.

Overweight and Obesity

With more than two-thirds the American population overweight or obese and numbers increasing,[44] RDNs should be aware of the evidence to support the use of vegetarian and vegan diets for achieving and maintaining a healthy weight. A healthy body weight is associated with improved cardiovascular function[45] and insulin sensitivity,[46] as well as helping to reduce the risk of other chronic diseases.[45]

Plant-based dietary patterns are also associated with lower body mass index (BMI; calculated as kg/m^2). In the Adventist Health Study-2, mean BMI was highest (28.8) in meat eaters and lowest in those who avoided all animal products (23.6).[47] Similarly, in the EPIC-Oxford Study, researchers found the highest mean BMI among meat eaters (24.4) and the lowest among vegans (22.5).[48] In the Swedish Mammography Cohort study, researchers found that the prevalence of overweight or obesity was 40% among omnivores and 25% among vegetarians.[49]

Research indicates that therapeutic use of a vegetarian diet is effective for treating overweight and may perform better than alternative omnivorous diets for the same purpose. Two meta-analyses of intervention trials showed that adoption of vegetarian diets was associated with greater weight loss compared with control diet groups.[50,51] A vegan diet with structured group support and behavioral therapy compared with the National Cholesterol Education Program diet, was associated with significantly greater weight loss after 1 and 2 years.[52]

CVD, Including Hyperlipidemia, Ischemic Heart Disease, and Hypertension

Vegetarian diets are associated with a reduction in the risk of CVD.[15,53] Vegetarian diets improve several modifiable heart disease risk factors, including abdominal obesity,[54] blood pressure,[55] serum lipid profile,[56] and blood glucose.[42,57] They also decrease markers of inflammation such as C-reactive protein, reduce oxidative stress, and protect from atherosclerotic plaque formation.[58] Consequently, vegetarians have reduced risk of developing and dying from ischemic heart disease.[15,53,59]

Vegan diets seem to be most beneficial in improving heart disease risk factors.[55,57] The EPIC-Oxford study[60] revealed that those who consumed a vegan diet ate the most fiber, the least total fat and saturated fat, and had the healthiest body weights and cholesterol levels compared with omnivores and other vegetarians. A meta-analysis of 11 randomized controlled trials found that those participants assigned to a vegetarian diet experienced a substantial reduction in total, low-density lipoprotein, and high-density lipoprotein cholesterol, which corresponded with an approximately 10% reduced risk of heart disease.[56] The vegetarian diet was especially beneficial for healthy weight and overweight individuals, but less effective for obese individuals, underscoring the importance of early dietary intervention for long-term risk reduction.[56]

In the Adventist Health Study-2 of 73,308 Seventh-day Adventists, researchers found that vegetarians had a 13% and 19% decreased risk for developing CVD and ischemic heart disease, respectively, compared with nonvegetarians.[15] A previous analysis from the EPIC study found that vegetarian groups had a 32% lower risk of hospitalization or death from heart disease.[53]

Vegetarians enjoy a lower risk of heart disease by regularly consuming a variety of vegetables, fruit, whole grains, legumes, and nuts. Low-fat vegan and vegetarian diets, combined with other lifestyle factors, including not smoking and weight reduction, have been shown to reverse atherosclerosis.[61] Risk factors for coronary heart disease, such as total and low-density lipoprotein cholesterol levels, body weight, and body fat, improve within a short time on a vegetarian diet, even without the use of cholesterol-lowering drugs.[61]

Compared with nonvegetarians, vegetarians have a lower prevalence of hypertension. Results of the EPIC-Oxford study showed vegans have the lowest systolic and diastolic blood pressure levels and the lowest rate of hypertension of all diet groups (vegans, vegetarians, fish eaters, and meat eaters).[62] Data from the Adventist Health Study-2 confirmed that vegans have the lowest blood pressure levels and the least hypertension of all vegetarians, and significantly less than the meat eaters.[55] A meta-analysis comparing blood pressure from more than 21,000 people around the world found that those who follow a vegetarian diet have systolic blood pressure about 7 mm Hg lower and diastolic blood pressure 5 mm Hg lower than study participants who consume an omnivorous diet.[63]

Diabetes

Compared with meat eaters, lacto-ovo-vegetarians and vegans have lower risk of type 2 diabetes. The Adventist Health Study-2 reported that meat eaters had more than twice the prevalence of diabetes compared with lacto-ovo-vegetarians and vegans, even after correcting for BMI.[47] Among those who were free of diabetes, the Adventist Health Study found that the odds of developing diabetes were reduced by 77% for vegans and by 54% for lacto-ovo-vegetarians compared with nonvegetarians (adjusting for age). When BMI and other confounding factors were adjusted for, the association remained strong. Vegans were 62% less likely to develop diabetes, while lacto-ovo-vegetarians were 38% less likely.[64]

Prevention. In the past 2 decades, prospective observational studies and clinical trials have provided significant evidence that diets rich in whole grains, fruits, vegetables, legumes, seeds, and nuts, and lower in refined grains, red or processed meats, and sugar-sweetened beverages, reduce the risk of diabetes and improve glycemic control and blood lipids in patients with diabetes.[65] Whole-grain intake has been consistently associated with a lower risk of diabetes, even after adjusting for BMI.[66] Legumes, which are low glycemic index foods, may provide benefit for diabetes by reducing postprandial glucose levels after consumption of a meal as well as after a subsequent meal, known as the "second-meal effect."[67] A meta-analysis demonstrated that higher intakes of fruit or vegetables, particularly green vegetables, were associated with a significant reduction in risk of type 2 diabetes.[68] In the Nurses' Health Study I and II, greater nut consumption, especially walnuts, was associated with a lower risk of diabetes.[69] Conversely, red and processed meats are strongly associated with increased fasting glucose and insulin concentrations and diabetes risk.[70] Potential etiologies for the association of meat and diabetes include saturated fatty acid, advanced glycation end products, nitrates/nitrites, heme iron, trimethylamine N-oxide, branched amino acids, and endocrine disruptor chemicals.[70]

Treatment. In a randomized clinical trial comparing a low-fat vegan diet to a diet based on the American Diabetes Association guidelines, greater improvements in glycemic control, blood lipids, and body weight were seen in the vegan group.[71] In a 24-week randomized controlled trial in patients with type 2 diabetes, those on an isocaloric vegetarian diet reported greater improvements of insulin sensitivity, reduction in visceral fat, and a reduction in inflammatory markers than those on a conventional diabetic diet.[72]

According to a meta-analysis of six controlled clinical trials, vegetarian diets were associated with improved glycemic control in people with type 2 diabetes.[73] Vegetarian and vegan dietary patterns characterized by nutrient-dense, high-fiber plant foods lower the risk of type 2 diabetes and serve as effective therapeutic tools in the management of type 2 diabetes.

Cancer

Results from the Adventist Health Study-2 revealed that vegetarian diets are associated with a lower overall cancer risk, and especially a lower risk of gastrointestinal cancer. Furthermore, a vegan diet appeared to confer a greater protection against overall cancer incidence than any other dietary pattern.[74] Recently, vegan diets were reported to confer about a 35% lower risk of prostate cancer.[75] A meta-analysis of seven studies reported vegetarians having an 18% lower overall cancer incidence than nonvegetarians.[59]

Epidemiologic studies have consistently shown that a regular consumption of fruit, vegetables, legumes, or whole grains is associated with a reduced risk of certain cancers.[76] A vast array of phytochemicals, such as sulforaphane, ferulic acid, genistein, indole-3-carbinol, curcumin, epigallocatechin-3-gallate, diallyldisulfide, resveratrol, lycopene, and quercetin found in vegetables, legumes, fruits, spices, and whole grains may provide protection against cancer.[77,78] These phytochemicals are known to interfere with a number of cellular processes involved in the progression of cancer.[79]

Vegetarians typically consume higher levels of fiber compared with other diets. The EPIC study involving 10 European countries reported a 25% reduction in risk of colorectal cancer for the highest intake of dietary fiber compared with the lowest.[80] On the other hand, in two large US cohorts, a positive association was observed between processed red meat consumption and risk of colorectal cancer.[81] Processed meat consumption was also seen to increase the risk of dying from cancer.[82] In a systematic review and meta-analysis of 26 epidemiological studies, the relative risk of colorectal adenomas was 1.27 per daily 100-g intake of red meat and 1.29 per daily 50-g intake of processed meat.[83]

Osteoporosis

Bone studies have reported that vegetarians have either similar or slightly reduced bone mineral density levels compared with omnivores, with vegans typically having the lowest levels.[84] While the differences are relatively modest, they appear not to be of clinical significance, provided the nutrients of concern are adequately provided.

Vegetarian diets are associated with several factors that promote bone health, including high intakes of vegetables and fruits; an abundant supply of magnesium, potassium, vitamin K, vitamin C; and a relatively low acid load.[36] Conversely, they can compromise bone health when low in calcium, vitamin D, vitamin B-12, and protein.[36] EPIC-Oxford reported a 30% increase in fracture risk of vegans as a group, but no increase in fracture risk in lacto-ovo-vegetarians compared to nonvegetarians. However, when only vegans with calcium intakes >525 mg/day were included in the analysis, differences in fracture risk disappeared.[84] The Adventist Health Study-2 reported that more frequent intakes of legumes and meat analogs reduced risk of hip fracture, with a greater protective effect than that of meat.[85] Protein has a neutral or slightly positive impact on bone health.[36] Inadequate intakes of vitamins D and B-12 have been linked to low bone mineral density, increased fracture risk, and osteoporosis.[36]

To achieve and maintain excellent bone health, vegetarians and vegans are well advised to meet the RDA for all nutrients, particularly calcium, vitamin D, vitamin B-12, and protein, and to consume generous servings of vegetables and fruits.[36]

VEGETARIAN DIETS THROUGHOUT THE LIFE CYCLE

Well-planned vegan, lacto-vegetarian, and lacto-ovo-vegetarian diets are appropriate, and they satisfy the nutrient needs and promote normal growth at all stages of the life cycle, including pregnancy and lactation, infancy, childhood, adolescence, older adulthood, and for athletes.

Pregnant and Lactating Women

Limited research indicates that where food access is adequate, vegetarian pregnancy outcomes, such as birth weight and pregnancy duration, are similar to those in nonvegetarian pregnancy.[7,86,87] Use of a vegetarian diet in the first trimester resulted in lower risk of excessive gestational weight gain in one study.[88] Maternal diets high in plant foods may reduce the risk of complications of pregnancy, such as gestational diabetes.[88,89]

The Academy of Nutrition and Dietetics' position and practice papers on "Nutrition and Lifestyle for a Healthy Pregnancy Outcome"[90,91] provide appropriate guidance for pregnant vegetarians. Special consideration is required for iron, zinc, vitamin B-12, and EPA/DHA.[87,89]

Depending on dietary choices, pregnant vegetarians may have higher iron intakes than nonvegetarians and are more likely to use iron supplements.[92] Because of the potential for inadequate intakes and the adverse effects of iron deficiency, a low-dose (30 mg) iron supplement is recommended in pregnancy.[93] The recommended amount of iron could be provided via a prenatal supplement, a separate iron supplement, or a combination of these. There is insufficient evidence that zinc intake and status in vegetarian pregnancies differ from nonvegetarian pregnancies.[87,89] Due to the increased zinc requirements of pregnancy and the lower bioavailability in diets based on high-phytate grains and legumes, increasing zinc intake and using food preparation techniques that improve bioavailability are recommended.[7,8,29] Pregnant and lactating vegetarians need regular and adequate dietary and/or supplemental sources of vitamin B-12.[7,8,89,91]

Infants of vegetarian women have lower plasma DHA concentrations and breast milk of vegetarians is lower in DHA.[7,8] These n-3 fatty acids can be synthesized to some extent from α-linolenic acid, but conversion rates are low (though somewhat enhanced in pregnancy).[8,89] Pregnant and lactating vegetarians may benefit from direct sources of EPA and DHA derived from microalgae.[8,91]

Infants, Children, and Adolescents

Exclusive breastfeeding is recommended for the first 6 months.[94] If breastfeeding is not possible, commercial infant formula should be used as the primary beverage for the first year. Complementary foods should be rich in energy, protein, iron, and zinc, and may include hummus, tofu, well-cooked legumes, and mashed avocado.[8] Full fat, fortified soy milk, or dairy milk can be started as early as 1 year of age for toddlers who are growing normally and eating a variety of foods.[95] Vegetarian children and teens are at lower risk than their nonvegetarian peers for overweight and obesity. Children and adolescents with BMI values in the normal range are more likely to also be within the normal range as adults, resulting in significant disease risk reduction.[96] Other benefits of a vegetarian diet in childhood and adolescence include greater consumption of fruits and vegetables, fewer sweets and salty snacks, and lower intakes of total and saturated fat.[97] Consuming balanced vegetarian diets early in life can establish healthful lifelong habits.[8]

The peak age of onset for the most common eating disorders is in the adolescent years. Eating disorders have a complex etiology and prior use of a vegetarian or vegan diet does not appear to increase the risk of an eating disorder, though some with pre-existing disordered eating may choose these diets to aid in their limitation of food intake.[7,8]

Nutrients that may require attention in the planning of nutritionally adequate diets for young vegetarians include iron, zinc, vitamin B-12, and for some, calcium and vitamin D. Mean protein intakes of vegetarian children generally meet or exceed recommendations.[7] Protein needs of vegan children may be slightly higher than those of nonvegan children because of differences in protein digestibility and amino acid composition.[7] Recommendations of 30% to 35% more protein for 1- to 2-year-old vegans, 20% to 30% more for 2 to 6 year olds, and 15% to 20% more for children older than 6 years have been suggested.[7,95] While dietary factors may limit absorption of iron and zinc, deficiencies of these minerals are uncommon in vegetarian children in industrialized countries.[98] Iron and zinc status of children on very restricted plant-based diets should be monitored. Supplemental iron and zinc may be needed in such cases.[98]

Vitamin B-12 intake of vegan infants and children should be assessed and fortified foods and/or supplements used as needed to insure adequacy.[7]

Older Adults

Nutrient intakes of older vegetarians appear to be similar to or better than those of older nonvegetarians,[7] although past research suggested lower zinc intakes and a greater incidence of poor iron status among vegetarians.[86,99] Caloric needs generally decrease with age, while requirements for some nutrients increase; thus, it is important that all older people choose nutrient-dense diets. Some evidence suggests that protein is used less efficiently with aging, which may translate to higher protein requirements.[100] Thus, it is important for older vegetarians and vegans to include protein-rich foods such as legumes and soy foods in their diets. Meat analogs may be helpful as protein sources. Older people synthesize vitamin D less efficiently, and are likely to require supplements, especially if sun exposure is limited.[35] The higher calcium recommendations for older adults may be met more easily when fortified foods, such as plant milks, are included. The requirement for vitamin B-6 increases with aging, and may be higher than current RDAs for older people. Atrophic gastritis is common among people over the age of 50 years and can result in decreased absorption of vitamin B-12 from animal products. Therefore, many older people, regardless of diet, require vitamin B-12 supplements.

ENVIRONMENTAL ISSUES

Plant-based diets are more environmentally sustainable than diets rich in animal products because they use fewer natural resources and are associated with considerably less environmental damage.[101-105] The current worldwide consumption of diets high in meat and

www.vndpg.org
The Vegetarian Nutrition Dietetic Practice Group (VNDPG) member benefits include professional information on vegetarian nutrition, RDN resources, and quarterly newsletters.

www.vegetariannutrition.net
VNDPG's consumer website provides a blog with evidence-based vegetarian nutrition plus RDN resources for consumers.

www.vrg.org
The Vegetarian Resource Group provides nutrition information, recipes, meal plans, and recommended readings for vegetarian nutrition.

www.PCRM.org
The Physicians Committee for Responsible Medicine promotes preventive medicine through innovative programs and offers free patient educational materials.

www.veganhealth.org
This website offers evidence-based recommendations covering the nutritional features of plant-based diets.

www.nutritionfacts.org
This website provides brief, referenced video clips and articles on numerous aspects of vegetarian nutrition.

www.vegweb.com
VegWeb offers vegetarian recipes, community, and a blog.

www.vegetarian-nutrition.info
Vegetarian Nutrition Info provides topical articles, resources, and news.

Figure 2. Professional and consumer websites for vegetarian nutrition, food, and related topics. Many of these sites provide high-quality educational materials upon which the registered dietitian nutritionist (RDN); nutrition and dietetics technician, registered; and other health care practitioners can rely. These sites supply patient or client education regarding vegetarian nutrition throughout the life cycle, nutrients of interest, meal plans, and plant-based substitutions for nonvegetarian ingredients.

dairy products is considered by some as unsustainable.[101,103,105] The systematic review conducted by the Scientific Committee of the Dietary Guidelines for Americans provides evidence that diets higher in plant foods and lower in animal foods (like a vegetarian diet) are associated with lower environmental damage.[106] Many scientists are calling for a substantial reduction of livestock products in the diet of humans as a major way to reverse climate change.[105] Compared with omnivorous diets, vegetarian diets utilize less water and fossil fuel resources and use lower amounts of pesticides and fertilizers.[107] Substituting beans for beef in the diet would significantly reduce the environmental footprint worldwide. To produce 1 kg protein from kidney beans requires 18 times less land, 10 times less water, 9 times less fuel, 12 times less fertilizer, and 10 times less pesticide in comparison to producing 1 kg protein from beef.[108] In addition, beef production generates considerably more manure waste than from any other animal food production.[108]

According to the US Environmental Protection Agency, about 70% of all water pollution in rivers and lakes in the United States is a result of pollution from animal farms.[109] Animal agriculture is associated with land degradation, air pollution, loss of biodiversity, and global warming.[104,110] Meat production makes a significant contribution to anthropogenic carbon dioxide emissions and anthropogenic methane and nitrous oxide production.[101,103,111] Using calculations based on 210 common foods, greenhouse gas emissions from consuming a vegetarian diet were found to be 29% lower than from the use of a nonvegetarian diet,[112] while a vegan diet can have >50% lower greenhouse emissions compared to a nonvegetarian diet.[102]

While new technologies for animal farming are available, a recent study found that greenhouse gas emissions from the production and consumption of animal products were reduced only 9% due to a more efficient livestock production.[113] The authors concluded that cuts in greenhouse gas emissions necessary to meet the global temperature target "imply a severe constraint on the long-term global consumption of animal food."[113] Others have suggested that reducing animal production has a greater potential to reduce greenhouse gas emissions than "technological mitigation or increased productivity measures."[105]

The use of antibiotics in farm animals as growth promoters and for the prevention and treatment of animal diseases has generated antibiotic-resistant bacteria. This antibiotic resistance can be transmitted to humans through animal food consumption and is now a major public health problem, causing illnesses that are difficult to treat, and resulting in increased morbidity, mortality, and health care costs.[105,114]

ROLES, RESPONSIBILITIES, AND RESOURCES FOR THE RDN AND NDTR

Vegan and vegetarian diets can provide significant health benefits compared with nonvegetarian diets. Ensuring energy balance; nutritional adequacy; and a focus on a variety of vegetables, legumes, fruits, whole grains, nuts, and seeds, can maximize these benefits. Nutrition and dietetics practitioners can play key roles in educating vegetarians about sources of specific nutrients and foods useful in the management of specific chronic diseases. In order to effectively counsel on the adoption and implementation of a vegetarian or vegan diet, RDNs and NDTRs must have adequate knowledge and access to educational materials to facilitate healthful recommendations. The US Department of Agriculture's ChooseMyPlate allows for lacto-ovo-vegetarian and vegan menus, listing beans and peas, nuts and seeds, and soy products as plant-based choices in the protein food group, as well as eggs for ovo-vegetarians.[115] Fortified soy milk is listed as an alternative for cow's milk and calcium-fortified foods (juices, cereals, breads, rice milk, and almond milk), as well as kale, are suggested as calcium choices.[116,117] Vegan food guides, all modeled on the US Department of Agriculture's ChooseMyPlate, are available online, and include specifications regarding sources of calcium, vitamin B-12, iodine, and n-3 fatty acids (www.vrg.org/nutshell/MyVeganPlate.pdf; www.becomingvegan.ca/food-guide; www.theveganrd.com/food-guide-for-vegans). Evidence-based RDN consumer and professional resources are available through the Vegetarian Nutrition Dietetic Practice Group's website (www.vegetariannutrition.net). These resources are regularly updated and provide information on critical nutrients and lifecycle issues in plant-based diets.

Figure 2 lists useful websites that promote and encourage appropriate evidence-based recommendations and food choices for both the RDN and clientele. Further recommendations can be found at the Evidence Analysis Library, a free benefit to all Academy of Nutrition and Dietetics members. In addition, all RDNs have ethical obligations to respect vegetarian dietary patterns as they would any other dietary pattern.

CONCLUSIONS

Interest in and appreciation for plant-based diets continue to grow in the United States and other parts of the world as governmental agencies and various health and nutrition organizations promote the regular use of plant foods. Abundant choices in the marketplace facilitate following a plant-based diet. Well-designed vegetarian diets provide adequate nutrient intakes for all stages of the lifecycle and can also be useful in the therapeutic management of some chronic diseases. Overall nutrition, as assessed by the Alternative Healthy Eating Index, is typically better on vegetarian and vegan diets compared with omnivorous diets. While some vegetarian diets may be low in certain nutrients, such as calcium and vitamin B-12, this can be remedied by appropriate planning. Compared to nonvegetarian diets, vegetarian diets can provide protection against many chronic diseases, such as heart disease, hypertension, type 2 diabetes, obesity, and some cancers. Furthermore, a vegetarian diet could make more conservative use of natural resources and cause less environmental degradation. Greater educational resources are available today, and RDNs and NDTRs have more current information on vegetarian diets to better assist the general public and vegetarian clients in making well-informed decisions about their nutritional health.

References

1. Stahler C. How often do Americans eat vegetarian meals? And how many adults in the US are vegetarian? The Vegetarian Resource Group website. http://www.vrg.org/nutshell/Polls/2016_adults_veg.htm. Accessed June 23, 2016.
2. Hoek AC, Luning PA, Weijzen P, Engels W, Kok FJ, de Graaf C. Replacement of meat by meat substitutes. A survey on person- and product-related factors in consumer acceptance. *Appetite*. 2011;56(3):662-673.
3. American Institute for Cancer Research. Recommendations for cancer prevention. http://www.aicr.org/reduce-your-cancer-risk/recommendations-for-cancer-prevention/recommendations_04_plant_based.html?gclid=CJ6__O7dpboCFcid4AodhkMAIA. Accessed June 23, 2016.
4. US Department of Agriculture, US Department of Health and Human Services. *2015-2020 Dietary Guidelines for Americans*. 8th ed. Washington, DC: US Government Printing Office; 2015. http://health.gov/dietaryguidelines/2015. Accessed June 23, 2016.
5. US Department of Agriculture. SuperTracker. https://www.supertracker.usda.gov/default.aspx. Accessed June 23, 2016.
6. Institute of Medicine. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids. http://www.nap.edu/download.php?record_id=10490. Accessed June 23, 2016.
7. Mangels R, Messina V, Messina M. *The Dietitian's Guide to Vegetarian Diets*. 3rd ed. Sudbury, MA: Jones and Bartlett; 2011.
8. Davis B, Melina V. *Becoming Vegan: Comprehensive Edition*. Summertown, TN: Book Publishing Co; 2014.
9. Messina V. Nutritional and health benefits of dried beans. *Am J Clin Nutr*. 2014;100(suppl 1):437S-442S.
10. Saunders AV, Davis BC, Garg ML. Omega-3 polyunsaturated fatty acids and vegetarian diets. *Med J Aust*. 2013;199(4 suppl):S22-S26.
11. Sanders TA. DHA status of vegetarians. *Prostaglandins Leukot Essent Fatty Acids*. 2009;81(2-3):137-141.
12. Sarter B, Kelsey KS, Schwartz TA, et al. Blood docosahexaenoic acid and eicosapentaenoic acid in vegans: Associations with age and gender and effects of an algal-derived omega-3 fatty acid supplement. *Clin Nutr*. 2015;34(2):212-218.
13. Gibson RA, Muhlhausler B, Makrides M. Conversion of linoleic acid and alpha-linolenic acid to long-chain polyunsaturated fatty acids (LCPUFAs), with a focus on pregnancy, lactation and the first 2 years of life. *Matern Child Nutr*. 2011;7(suppl 2):17-26.
14. Rosell MS, Lloyd-Wright Z, Appleby PN, et al. Long-chain n-3 polyunsaturated fatty acids in plasma in British meat-eating, vegetarian, and vegan men. *Am J Clin Nutr*. 2005;82(2):327-334.
15. Orlich MJ, Singh PN, Sabaté J, et al. Vegetarian dietary patterns and mortality in Adventist Health Study 2. *JAMA Intern Med*. 2013;173(13):1230-1238.
16. Van Dokkum W. Significance of iron bioavailability for iron recommendations. *Biol Trace Elem Res*. 1992;35(1):1-11.
17. Rizzo NS, Jaceldo-Siegl K, Sabate J, Fraser GE. Nutrient profiles of vegetarian and nonvegetarian dietary patterns. *J Acad Nutr Diet*. 2013;113(12):1610-1619.
18. Park SK, Ryoo JH, Kim MG, Shin JY. Association of serum ferritin and the development of metabolic syndrome in middle-aged Korean men: A 5-year follow-up study. *Diabetes Care*. 2012;35(12):2521-2526.
19. Craig WJ. Iron status of vegetarians. *Am J Clin Nutr*. 1994;59(5 suppl):1233S-1237S.
20. Collings R, Harvey LJ, Hooper L, et al. The absorption of iron from whole diets: A systematic review. *Am J Clin Nutr*. 2013;98(1):65-81.
21. Food and Nutrition Board, Institute of Medicine. Iron. In: *Dietary References Intake for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium and Zinc*. Washington, DC: The National Academies Press; 2001:290-393.
22. Hunt JR, Roughead ZK. Adaptation of iron absorption in men consuming diets with high or low iron bioavailability. *Am J Clin Nutr*. 2000;71(1):94-102.
23. Armah SM, Carriquiry A, Sullivan D, Cook JD, Reddy MB. A complete diet-based algorithm for predicting nonheme iron absorption in adults. *J Nutr*. 2013;143(7):1136-1140.

24. Hunt JR, Roughead ZK. Nonheme-iron absorption, fecal ferritin excretion, and blood indexes of iron status in women consuming controlled lactoovovegetarian diets for 8 weeks. *Am J Clin Nutr*. 1999;69(5):944-952.

25. Foster M, Samman S. Vegetarian diets across the lifecycle: Impact on zinc intake and status. *Adv Food Nutr Res*. 2015;74:93-131.

26. Lonnerdal B. Dietary factors influencing zinc absorption. *J Nutr*. 2000;130(5 suppl):1378S-1383S.

27. Leung AM, Lamar A, He X, et al. Iodine status and thyroid function of Boston-area vegetarians and vegans. *J Clin Endocrinol Metab*. 2011;96(8):E1303-E1307.

28. Teas J, Pino S, Critchley A, Braverman LE. Variability of iodine content in common commercially available edible seaweeds. *Thyroid*. 2004;14(10):836-841.

29. Institute of Medicine. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. www.iom.edu/Reports/2001/Dietary-Reference-Intakes-for-Vitamin-A-Vitamin-K-Arsenic-Boron-Chromium-Copper-Iodine-Iron-Manganese-Molybdenum-Nickel-Silicon-Vanadium-and-Zinc.aspx#sthash.gITnT436.dpuf Published 2010. Accessed June 23, 2016.

30. Messina M, Redmond G. Effects of soy protein and soybean isoflavones on thyroid function in healthy adults and hypothyroid patients: A review of the relevant literature. *Thyroid*. 2006;16:249-258.

31. Weaver CM, Proulx WR, Heaney R. Choices for achieving adequate dietary calcium with a vegetarian diet. *Am J Clin Nutr*. 1999;70(3):543S-548S.

32. Tang AL, Walker KZ, Wilcox G, Strauss BJ, Ashton JF, Stojanovska L. Calcium absorption in Australian osteopenic post-menopausal women: An acute comparative study of fortified soymilk to cows' milk. *Asia Pac J Clin Nutr*. 2010;19(2):243-249.

33. Zhao Y, Martin BR, Weaver CM. Calcium bioavailability of calcium carbonate fortified soymilk is equivalent to cow's milk in young women. *J Nutr*. 2005;135(10):2379-2382.

34. Patrick L. Comparative absorption of calcium sources and calcium citrate malate for the prevention of osteoporosis. *Altern Med Rev*. 1999;4(2):74-85.

35. Wacker M, Holick MF. Sunlight and vitamin D: A global perspective for health. *Dermatoendocrinol*. 2013;5(1):51-108.

36. Mangels AR. Bone nutrients for vegetarians. *Am J Clin Nutr*. 2014;100(suppl 1):469S-475S.

37. Keegan RJ, Lu Z, Bogusz JM, Williams JE, Holick MF. Photobiology of vitamin D in mushrooms and its bioavailability in humans. *Dermatoendocrinology*. 2013;5(1):165-176.

38. Food and Nutrition Board, Institute of Medicine. *Dietary Reference Intakes for Calcium and Vitamin D*. Washington, DC: The National Academies Press; 2011. www.nap.edu/download.php?record_id=13050. Accessed June 23, 2016.

39. Norris, J. Vitamin B12 recommendations. www.veganhealth.org/b12/rec. Accessed June 23, 2016.

40. Food and Nutrition Board, Institute of Medicine. *Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline*. Washington, DC: The National Academies Press; 1998. http://www.ncbi.nlm.nih.gov/books/NBK114310/. Accessed June 23, 2016.

41. Donaldson MS. Metabolic vitamin B12 status on a mostly raw vegan diet with follow-up using tablets, nutritional yeast, or probiotic supplements. *Ann Nutr Metab*. 2000;44(5-6):229-234.

42. Obeid R, Fedosov SN, Nexo E. Cobalamin coenzyme forms are not likely to be superior to cyano- and hydroxyl-cobalamin in prevention or treatment of cobalamin deficiency. *Mol Nutr Food Res*. 2015;59(7):1364-1372.

43. Moore WJ, McGrievy ME, Turner-McGrievy GM. Dietary adherence and acceptability of five different diets, including vegan and vegetarian diets, for weight loss: The New DIETs study. *Eat Behav*. 2015;19:33-38.

44. US Department of Health and Human Services. Center for Disease Control and Prevention. Health, United States, 2012. http://www.cdc.gov/nchs/data/hus/hus12.pdf#063. Accessed June 23, 2016.

45. National Institutes of Health; National Heart, Lung, and Blood Institute and National Institute of Diabetes and Digestive and Kidney Diseases. *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report*. Bethesda, MD: National Institutes of Health; 1998.

46. Schindler TH, Cardenas J, Prior JO. Relationship between increasing body weight, insulin resistance, inflammation, adipocytokine leptin, and coronary circulatory function. *J Am Coll Cardiol*. 2006;47(6):1188-1195.

47. 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.

48. Spencer EA, Appleby PN, Davey GK, Key TJ. Diet and body mass index in 38000 EPIC-Oxford meat-eaters, fish-eaters, vegetarians and vegans. *Int J Obes Relat Metab Disord*. 2003;27(6):728-734.

49. Newby PK, Tucker KL, Wolk A. Risk of overweight and obesity among semi-vegetarian, lactovegetarian, and vegan women. *Am J Clin Nutr*. 2005;81(6):1267-1274.

50. Barnard NB, Levin SM, Yokoyama Y. A systematic review and meta-analysis of change in body weight in clinical trials of vegetarian diets. *J Acad Nutr Diet*. 2015;115(6):954-969.

51. Huang RY, Huang CC, Hu FB, Chavarro JE. Vegetarian diets and weight reduction: A meta-analysis of randomized controlled trials. *J Gen Intern Med*. 2015;31(1):109-116.

52. Turner-McGrievy GM, Barnard ND, Scialli AR. A two-year randomized weight loss trial comparing a vegan diet to a more moderate low-fat diet. *Obesity*. 2007;15(9):2276-2281.

53. Crowe FL, Appleby PN, Travis RC, Key TJ. Risk of hospitalization or death from ischemic heart disease among British vegetarians and nonvegetarians: Results from the EPIC-Oxford cohort study. *Am J Clin Nutr*. 2013;97(3):597-603.

54. Rizzo NS, Sabaté J, Jaceldo-Siegl K, Fraser GE. Vegetarian dietary patterns are associated with a lower risk of metabolic syndrome: The Adventist Health Study 2. *Diabetes Care*. 2011;34(5):1225-1227.

55. Pettersen BJ, Anousheh R, Fan J, Jaceldo-Siegl K, Fraser GE. Vegetarian diets and blood pressure among white subjects: Results from the Adventist Health Study-2 (AHS-2). *Public Health Nutr*. 2012;15(10):1909-1916.

56. Wang F, Zheng J, Yang B, Jiang J, Fu Y, Li D. Effects of vegetarian diets on blood lipids: A systematic review and meta-analysis of randomized controlled trials. *J Am Heart Assoc*. 2015;4(10):e002408.

57. Barnard ND, Katcher HI, Jenkins DJ, Cohen J, Turner-McGrievy G. Vegetarian and vegan diets in type 2 diabetes management. *Nutr Rev*. 2009;67(5):255-263.

58. Yang SY, Li XJ, Zhang W, et al. Chinese lacto-vegetarian diet exerts favorable effects on metabolic parameters, intima-media thickness, and cardiovascular risks in healthy men. *Nutr Clin Pract*. 2012;627(3):392-398.

59. 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.

60. Bradbury KE, Crowe FL, Appleby PN, Schmidt JA, Travis RC, Key TJ. Serum concentrations of cholesterol, apolipoprotein A-I and apolipoprotein B in a total of 1694 meat-eaters, fish-eaters, vegetarians and vegans. *Eur J Clin Nutr*. 2014;68(2):178-183.

61. Ornish D, Brown S, Scherwitz L, et al. Can lifestyle changes reverse coronary heart disease? *Lancet*. 1990;336(15):129-133.

62. Appleby PN, Davey GK, Key TJ. Hypertension and blood pressure among meat eaters, fish eaters, vegetarians and vegans in EPIC–Oxford. *Public Health Nutr*. 2002;5(5):645-654.

63. Yokoyama Y, Nishimura K, Barnard ND, et al. Vegetarian diets and blood pressure: A meta-analysis. *JAMA Intern Med*. 2014;174(4):577-587.

64. Tonstad S, Stewart K, Oda K, Batech M, Herring RP, Fraser GE. Vegetarian diets and incidence of diabetes in the Adventist Health Study-2. *Nutr Metab Cardiovasc Dis*. 2013;23(4):292-299.

65. Ley SH, Hamdy O, Mohan v, Hu FB. Prevention and management of type 2 diabetes: Dietary components and nutritional strategies. *Lancet*. 2014;383(9933):1999-2007.

66. Aune D, Norat T, Romundstad P, Vatten LJ. Whole grain and refined grain consumption and the risk of type 2 diabetes: A systematic review and dose-response. *Eur J Epidemiol*. 2013;28(11):845-858.

67. Brighenti F, Benini L, Del Rio D, et al. Colonic fermentation of indigestible carbohydrates contributes to the second-meal effect. *Am J Clin Nutr*. 2006;83(4):817-822.

68. Li M, Fan Y, Zhang X, et al. Fruit and vegetable intake and risk of type 2 diabetes mellitus: Meta-analysis of prospective cohort studies. *BMJ Open*. 2014;4(11):e005497.

69. Pan A, Sun Q, Mason JE, et al. Walnut consumption is associated with lower risk of type 2 diabetes in women. *J Nutr*. 2013;143(4):512-518.

70. Kim Y, Keogh J, Clifton P. A review of potential metabolic etiologies of the observed association between red meat consumption and development of type 2 diabetes. *Metabolism*. 2015;64(7):768-779.

71. Barnard N, Cohen J, Jenkins DJ, et al. A low-fat vegan diet improves glycemic control and cardiovascular risk factors in a randomized clinical trial in individuals with type 2 diabetes. *Diabetes Care*. 2006;29(8):1777-1783.

72. Kahleova H, Matoulek M, Malinska O, et al. Vegetarian diet improves insulin resistance and oxidative stress markers more than conventional diet in subjects with type 2 diabetes. *Diabet Med*. 2011;28(5):549-559.

73. 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.

74. Tantamango-Bartley Y, Jaceldo-Siegl K, Fan J, Fraser G. Vegetarian diets and the incidence of cancer in a low-risk population. *Cancer Epidemiol Biomarkers Prev*. 2013;22(2):286-294.

75. Tantamango-Bartley Y, Knutsen SF, Knutsen R, et al. Are strict vegetarians protected against prostate cancer? *Am J Clin Nutr*. 2016;103(1):153-160.

76. World Cancer Research Fund. *Food, Nutrition, Physical Activity, and the Prevention of Cancer: A Global Perspective*. Washington, DC: American Institute for Cancer Research; 2007.

77. Anand P, Kunnumakkara AB, Sundaram C, et al. Cancer is a preventable disease that requires major lifestyle changes. *Pharm Res*. 2008;25(9):2097-2116.

78. Zhang Y, Gan R, Li S, et al. Antioxidant phytochemicals for prevention and treatment of chronic diseases. *Molecules*. 2015;20(12):21138-21156.

79. Thakur VS, Deb G, Babcook MA, Gupta S. Plant phytochemicals as epigenetic modulators: Role in cancer chemoprevention. *AAPS J*. 2014;16(1):151-163.

80. Bingham SA, Day NE, Luben R, et al. Dietary fibre in food and protection against colorectal cancer in the European Prospective Investigation into Cancer and Nutrition (EPIC): An observational study. *Lancet*. 2003;361(9368):1496-1501.

81. Bernstein AM, Song M, Zhang X, et al. Processed and unprocessed red meat and risk of colorectal cancer: Analysis by tumor location and modification by time. *PLoS One*. 2015;10(8):e0135959.

82. Rohrmann S, Overvad K, Bueno-de-Mesquita HB, et al. Meat consumption and mortality—Results from the European Prospective Investigation into Cancer and Nutrition. *BMC Med*. 2013,11:63.

83. Aune D, Chan DS, Vieira AR, et al. Red and processed meat intake and risk of colorectal adenomas: A systematic review and meta-analysis of epidemiological studies. *Cancer Causes Control*. 2013;24(4):611-627.

84. 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.

85. Lousuebsakul-Matthews V, Thorpe DL, Knutsen R, Beeson WL, Fraser GE, Knutsen SF. Legumes and meat analogues consumption are associated with hip fracture risk independently of meat intake among Caucasian men and women: The Adventist Health Study-2. *Public Health Nutr*. 2014;17(10):2333-2343.

86. Evidence Analysis Library. Pregnancy and nutrition-vegetarian nutrition. 2007. http://andevidencelibrary.com/topic.cfm?cat=4322. Accessed June 23, 2016.

87. Piccoli GB, Clari R, Vigotti FN, et al. Vegan-vegetarian diets in pregnancy: Danger or panacea? A systematic narrative review. *BJOG*. 2015;122(5):623-633.

88. Stuebe AM, Oken E, Gillman MW. Associations of diet and physical activity during pregnancy with risk for excessive gestational weight gain. *Am J Obstet Gynecol*. 2009;201(1). 58.e1-e8.

89. Pistollato F, Sumalla Cano S, Elio I, et al. Plant-based and plant-rich diet patterns during gestation: Beneficial effects and possible shortcomings. *Adv Nutr*. 2015;6(5):581-591.

90. Procter SB, Campbell CG. Position of the Academy of Nutrition and Dietetics: Nutrition and lifestyle for a healthy pregnancy outcome. *J Acad Nutr Diet*. 2014;114(7):1099-1103. www.andjrnl.org/article/S2212-2672%2814%2900501-2/pdf. Accessed June 23, 2016.

91. Kaiser LL, Campbell CG; ; Academy Positions Committee Workgroup. Practice paper of the Academy of Nutrition and Dietetics abstract: Nutrition and lifestyle for a healthy pregnancy outcome. *J Acad Nutr Diet*. 2014;114(9):1447.

92. Alwan NA, Greenwood DC, Simpson NA, McArdle HJ, Godfrey KM, Cade JE. Dietary iron intake during early pregnancy and birth outcomes in a cohort of British women. *Hum Reprod*. 2011;26(4):911-919.

93. Centers for Disease Control and Prevention. Recommendations to prevent and control iron deficiency in the United States. *Morb Mortal Wkly Rep*. 1998;47(RR-3):1-29.

94. Breastfeeding and the use of human milk. *Pediatrics*. 2012;129(3):e827-e841.

95. Mangels AR, Messina V. Considerations in planning vegan diets: Infants. *J Am Diet Assoc*. 2001;101(6):670-677.

96. Sabaté J, Wien M. Vegetarian diets and childhood obesity prevention. *Am J Clin Nutr*. 2010;91(5):1525S-1529S. http://ajcn.nutrition.org/content/91/5/1525S.long. Accessed June 23, 2016.

97. Evidence Analysis Library. Vegetarian nutrition: Adolescence. 2009. http://www.andeal.org/topic.cfm?menu=5271&pcat=3105&cat=4019. Accessed June 23, 2016.

98. Gibson RS, Heath AL, Szymlek-Gay EA. Is iron and zinc nutrition a concern for vegetarian infants and young children in industrialized countries? *Am J Clin Nutr*. 2014;100(suppl 1):459S-468S.

99. Brants HA, Lowik MR, Westenbrink S, Hulshof KF, Kistemaker C. Adequacy of a vegetarian diet at old age (Dutch Nutrition Surveillance System). *J Am Coll Nutr*. 1990;9(4):292-302.

100. Kurpad AV, Vaz M. Protein and amino acid requirements in the elderly. *Eur J Clin Nutr*. 2000;54(suppl 3):S131-S142.

101. Hedenus F, Wirsenius S, Johansson DJA. The importance of reduced meat and dairy consumption for meeting stringent climate change targets. *Climatic Change*. 2014;124(1):79-91.

102. Hallström E, Carlsson-Kanyama A, Börjesson P. Environmental impact of dietary change: A systematic review. *J Cleaner Prod*. 2015;91:1-11.

103. Davidson EA. Representative concentration pathways and mitigation scenarios for nitrous oxide. *Environ Res Lett*. 2012;7(2):024005.

104. Stehfest EBL, van Vuuren DP, den Elzen MGJ, Eickhout B, Kabat P. Climate benefits of changing diet. *Climate Change*. 2009;95(1-2):83-102.

105. Raphaely T, Marinova D. *Impact of Meat Consumption on Health and Environmental Sustainability*. Hershey, PA: IGI Global; 2016.

106. Dietary Guidelines Advisory Committee. Scientific Report of the 2015 Dietary Guidelines Advisory Committee—Part D. Chapter 5: Food Sustainability and Safety. https://health.gov/dietaryguidelines/2015-scientific-report/PDFs/10-Part-D-Chapter-5.pdf. Updated January 28, 2015. Accessed September 19, 2016.

107. Marlow HJ, Harwatt H, Soret S, Sabaté J. Comparing the water, energy, pesticide and fertilizer usage for the production of foods consumed by different dietary types in California. *Public Health Nutr*. 2015;18(13):2425-2432.

108. Sranacharoenpong K, Soret S, Harwatt H, Wien M, Sabate J. The environmental cost of protein food choices. *Public Health Nutr*. 2015;18(11):2067-2073.

109. Environmental Protection Agency. Environmental assessment of proposed revisions to the national pollutant discharge elimination system regulation and the effluent guidelines for concentrated animal farming operations. Environmental Protection Agency, Office of Water.

EPA Number 821B01001. https://www3.epa.gov/npdes/pubs/cafo_proposed_env_assess_ch1-3.pdf. Published January 2001. Accessed September 14, 2016.

110. Machovina B, Feeley KJ, Ripple WJ. Biodiversity conservation: The key is reducing meat consumption. *Sci Total Environ*. 2015;536:419-431.

111. Ripple WJ, Smith P, Haberl H, Montzka SA, McAlpine C, Boucher DH. Ruminants, climate change and climate policy. *Nat Climate Change*. 2014;4(1):2-5.

112. Soret S, Mejia A, Batech M, Jaceldo-Siegl K, Harwatt H, Sabate J. Climate change mitigation and health effects of varied dietary patterns in real-life settings throughout North America. *Am J Clin Nutr*. 2014;100(suppl 1):490S-495S.

113. Cederberg C, Hedenus F, Wirsenius S, Sonesson U. Trends in greenhouse gas emissions from consumption and production of animal food products—Implications for long-term climate targets. *Animal*. 2013;7(2):330-340.

114. Economou V, Gousia P. Agriculture and food animals as a source of antimicrobial-resistant bacteria. *Infect Drug Resist*. 2015;8:49-61.

115. US Department of Agriculture. All about the protein foods group. http://www.choosemyplate.gov/protein-foods. Updated July 29, 2016. Accessed September 14, 2016.

116. US Department of Agriculture. All about the dairy group. http://www.choosemyplate.gov/dairy. Updated July 29, 2016. Accessed September 14, 2016.

117. US Department of Agriculture. Non-dairy sources of calcium. http://www.choosemyplate.gov/dairy-calcium-sources. Updated January 12, 2016. Accessed September 14, 2016.

This Academy of Nutrition and Dietetics position was adopted by the House of Delegates Leadership Team on October 18, 1987 and reaffirmed on September 12, 1992; September 6, 1996; June 22, 2000; June 11, 2006; and March 19, 2012. This position is in effect until December 31, 2021. Position papers should not be used to indicate endorsement of products or services. All requests to use portions of the position or republish in its entirety must be directed to the Academy at journal@eatright.org.

Authors: Vesanto Melina, MS, RD (Consultant, Vancouver, Canada); Winston Craig, PhD, MPH, RD (Andrews University, Berrien Springs, MI); Susan Levin, MS, RD, CSSD (Physicians Committee for Responsible Medicine, Washington, DC).

STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

FUNDING/SUPPORT

There is no funding to disclose.

Reviewers: Hunger and Environmental Nutrition dietetic practice group (Melissa Altman-Traub, MS, RDN, LDN, Community College of Philadelphia, Philadelphia, PA); Catherine Conway, MS, RDN, CDN, CDE (YAI/National Institute for People with Disabilities, New York, New York); Sharon Denny, MS, RD (Academy Knowledge Center, Chicago, IL); Sarah Picklo Halabu, RDN, LDN, CDE (Academy Publications and Resources, Chicago, IL); D. Enette Larson-Meyer, PhD, RD, CSSD (University of Wyoming, Laramie, WY); Mark E. Rifkin, MS, RD (Academy Policy Initiatives & Advocacy, Washington, DC); Tamara Schryver, PhD, MS, RD (The Schwan Food Company, Minneapolis, MN); Alison Steiber, PhD, RD (Academy Research, International and Scientific Affairs, Chicago, IL); Vegetarian Nutrition dietetic practice group (John Westerdahl, PhD, MPH, RD, CNS, FAND, Bragg Health Foundation, Santa Barbara, CA).

Academy Positions Committee Workgroup: Mary Ellen E. Posthauer, RDN, CD, LD, FAND (chair) (MEP Healthcare Dietary Services, Inc, Evansville, IN); Ainsley Malone, MS, RD, LD, CNSC, FAND, FASPEN (American Society for Parenteral and Enteral Nutrition, New Albany, OH); Joan Sabate, MD, DrPH (content advisor) (Loma Linda University, Loma Linda, CA).

The authors thank the reviewers for their many constructive comments and suggestions. The reviewers were not asked to endorse this position or the supporting paper.