Chapter 106. Nutritional Implications of Vegetarian Diets

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For centuries, vegetarian diets have been used to meet nutritional needs, perhaps most often out of economic necessity in underdeveloped countries. Nonetheless, even ancient times some advocated such diets for a variety of health-related, religious, or ethical reasons. Pythagoras is considered the founder of the vegetarian movement; advocates included other ancient Greeks. Eastern religions, including Buddhism, Zainism, and Hinduism, also promoted vegetarian diets and continue to urge preservation of animal life; vegetarians are found among their adherents.

In the 18th century, Benjamin Franklin was perhaps the most famous of the scientists, physicians, and philosophers who supported vegetarian diets. The vegetarian movement expanded considerably in the 19th century with the formation of societies, establishment of health care facilities, publication of books, and opening of restaurants, all promoting vegetarian diets. The 20th century witnessed a further expansion of interest and knowledge. Details of the history of vegetarian dietary practices can be found in recent reviews (1, 2).

A 1994 survey reported that some 12.4 million people in the United States call themselves vegetarians (3). This represents approximately 7% of the population and a near doubling in number of reported vegetarians over an 8-year period. It is predicted that 10% of all Americans will consider themselves vegetarians by the year 2000 (4).

The growing vegetarian population necessitates that health professionals be informed about the potential benefits and risks associated with these dietary practices. Position papers and scientific reviews have been published, as well as the proceedings from two international congresses addressing this topic (5-8); proceedings from the third, held in 1997, are under review. A recent monograph addresses virtually all topics related to the nutritional status of vegetarians and provides useful summaries of the literature as well as dietary suggestions for different conditions (9).

DEFINITIONS AND RATIONALE FOR VEGETARIAN DIETARY PRACTICES

The term *vegetarian* encompasses a wide range of dietary practices with potentially differing implications for health. It is not uncommon for individuals who call themselves vegetarians to consume meat. It was recently reported that 20% of vegetarians said they ate meat at least once a month (4). Consumption of fish or poultry is even more common.

The varied dietary practices result in differing nutritional intakes and necessitate that health professionals ascertain what actually is eaten rather than depend on what persons call themselves. Unfortunately, there is no consistent definition for vegetarian in the various scientific studies, although researchers may classify subjects on reported dietary intake rather than on what the subjects call themselves or their diets.

Cereal grains, fruits, vegetables, legumes, nuts, and seeds form the basis of vegetarian diets, with varying amounts of dairy products, with or without eggs. The types of animal products included frequently are used to identify the kind of vegetarian diet. Lactoovovegetarians (LOVs), sometimes called

ovolactovegetarians, and lactovegetarians are the largest subgroups. Both exclude meat, poultry, fish, and other seafood.

It is quite common for nonvegetarians to believe that vegetarians eat fish; while this may be true in some cases, it is not true of all vegetarians. Those who include fish may be called pescovegetarians, and those who include poultry may be called pollovegetarians; however, they are more commonly classified as semivegetarians, with individuals who are occasional or infrequent meat eaters.

Persons who exclude all animal products may be called strict, total, or pure vegetarians. However, these descriptors are also sometimes used, albeit inaccurately, to mean simply exclusion of flesh foods. The term *vegan* is explicitly used to define individuals who do not use any animal products. Some vegans also refrain from using honey and animal products such as leather or wool. Only 4% of vegetarians report they are vegans (4).

Additional subgroups of vegetarians or near vegetarians have been reported in recent years. In the 1970s, individuals who did not belong to vegetarian groups common at the time and who did not fit the usual definitions for vegetarians were classified as "new" vegetarians. The rationales for their dietary practices and actual food choices differed considerably among them.

Macrobiotic diets are often classified as vegetarian, although they may include fish. The macrobiotic diets of today are an outgrowth of a 10-step approach to eating that culminated in a diet composed almost exclusively of brown rice. This diet resulted in severe nutritional deficiencies and has since been modified. Although it still emphasizes brown rice and other whole grains, it also includes sea vegetables, legumes, and root vegetables. Animal foods are limited to white-meat fish, once or twice a week. Standard macrobiotic diet recommendations include 50 to 60% whole grains, 20 to 25% vegetables, 10% beans and sea vegetables, and 5% soups. Locally grown fruit may be consumed occasionally in season. Meat, poultry, eggs, dairy products, butter, yogurt, sugar, honey, and artificial sweeteners are to be avoided.

Occasionally, a fruitarian may be encountered or an individual who consumes only raw foods. The fruitarian diet consists of fruits (including those vegetables botanically classified as such), nuts, and seeds. A raw food diet, also called "living food diet," includes uncooked, fermented, or sprouted plant foods and the juice made from sprouts.

Thus a broad spectrum of dietary practices maybe classified as vegetarian. Regardless of how persons identify themselves, so far as dietary practices are concerned, actual dietary intake must be ascertained before effective nutritional intervention can take place. Knowledge of why an individual follows particular dietary practices is also helpful in developing an appropriate counseling approach.

Although, historically, vegetarian diets were associated with certain religious practices, currently, health appears to be the primary reason for adopting a vegetarian diet (4). The second reason encompasses ecologic and environmental issues relating to the large differences in resources necessary to support animal- and plant-based diets. The third currently most common reason relates tc ethical concerns about the treatment of animals and may extend to the use of animals for clothing or research. In many cases, however, multiple reasons underlie vegetarian dietary practices.

The differing reasons for adopting a vegetarian diet may affect food choices and subsequently nutritional status. In addition, the rationale for a particular diet maybe associated with other lifestyle practices that can affect health. Thus, ascertaining these reasons and associated practices is an important aspect of a patient's history.

DIETARY INTAKE AND NUTRITIONAL STATUS AMONG VEGETARIANS

There are many and varied ways to meet nutrient needs, and the adequacy of a diet depends not on what it is called but on the foods that are included. A vegetarian diet need not be deficient in nutrients; however, the more foods eliminated from any diet, the greater the risk of deficiency.

Most vegetarians ingest an adequate diet; however, those following restrictive dietary patterns may not, and these engender significant concern, especially when they include pregnant and lactating women, infants, children and the elderly. As our understanding of both beneficial and problematic aspects of vegetarian dietary practices grows, it allows us to focus our attention on those issues of greatest consequence for preventing disease and promoting health. Thus, our attention here addresses those questions that are most frequently raised.

Dietary Intake

Energy

Energy Intake and Weight Status. Some, but not all, investigators report that vegetarians weigh less than non-vegetarians, with the difference being least among the LOVs and greatest among the vegans. The lower weight among vegetarians is consistent with the lower intake of calories often reported. The energy-yielding nutrients of protein and fat are generally consumed in somewhat greater amounts by nonvegetarians, while larger amounts of carbohydrates are consumed by vegetarians. The result of this difference is that vegetarians may more closely approximate dietary recommendations for the distribution of macronutrients than do omnivores, and they may be closer to desirable weight.

A variety of other reasons have been suggested for the weight difference. In addition to the higher intake of carbohydrates, which may be less efficiently converted to body fat, they include perhaps greater control of food intake, possibly greater physical activity, and greater intake of fiber, which may enhance satiation (10).

Although overweight is a frequent concern in the

general population, maintaining adequate weight through appropriate caloric intake may be a concern to some vegetarians. Those at risk include children, adolescents, the elderly, and those who include no added oils or fat in the diet.

Vegetarian Diets and Weight Loss. The general understanding that vegetarian diets are associated with lower weight status may be the rationale for some females to adopt such a diet in hope of weight loss. Vegetarian dietary practices have been found among anorexia nervosa patients, although most were not vegetarians prior to the anorexia. It was suggested that vegetarian diets are a covenient and socially acceptable way to reduce caloric intake (11). A recent study of eating behavior found that vegetarian women had lower dietary restraint scores, indicating they were not motivated by weight loss to adopt the vegetarian diet (12). Thus, it is inappropriate to conclude that vegetarians are more prone to eating disorders than general population.

Protein

One of the most frequent questions regarding the nutritional adequacy of vegetarian diets relates to protein, yet there is little supporting evidence for such concerns with usual dietary intake in healthy vegetarians. However, the adequate energy intake seen in some vegetarians may compromise protein status.

Nutritional Quality of Plant Proteins. The nutritional quality of plant proteins may be underestimated in studies of animals, because animals have greater protein needs than humans. More relevant human data confirm the adequacy of plant proteins to meet the needs of both adults and children. Plant foods are often said to lack certain indispensable amino acids and thus be of lesser quality than animal foods. Although a certain plant food may be low in a specific amino acid, it is inaccurate to say it is incomplete. A single plant food, if fed as the only protein source, may prove inadequate; however, this is likely to occur only in a research setting. Appropriate mixtures of foods are equivalent to animal protein in quality and are commonly consumed.

Amino Acids. Two amino acids are of particular interest in vegetarian diets: lysine, the limiting amino acid cereal grains, and methionine, the limiting amino acid in legumes. Lysine occurs in significant amounts in the intracellular spaces of the skeletal musculature where it is deposited after a protein-rich meal (13). Subsequently, it is available to buffer a low-lysine amino acid mixture resulting from consumption of a meal deficient in this amino acid.

Methionine is of interest because it is the limiting amino acid in soy and other legumes, often a major source protein in vegetarian diets. Soy protein isolates have used successfully to refeed children recovering from malnutrition; they provide a protein quality comparable to that of milk. They may be used as the sole source of protein for adults and children; however modest supplementation with methionine may be appropriate for soy-based infant formulas, although the amount needed is lower than predicted from rat studies (13).

Complementation. Protein complementation occurs when a food low in a particular amino acid is combined with a food containing an adequate amount of that amino acid. Animal studies have influenced our attitudes toward combining complementary proteins within one meal. In these studies, an amino acid otherwise absent from the diet was added several hours later. Such a delay in providing a supplementary amino acid to rapidly growing rats and pigs affects protein use. Similar effects were not seen in human adults when the plant protein was distributed among several meals. The supplementary effect was somewhat lower in young children when the proteins were fed at intervals longer than 6 hours; however; this is a longer period than usual in young children, and meals are not entirely devoid of an amino acid as in the laboratory studies (13). It can be concluded that combinations of plant foods consumed throughout the day provide adequate amino acids for nitrogen retention and use.

Digestibility. Plant proteins in their natural form are, in general, less digestible than animal protein sources. Well-processed soy isolates, however, are as digestible as egg protein (13). Processing methods may have beneficial or detrimental effects on the nutritional quality of plant proteins. Consuming a broad variety of foods prepared in many different ways ensures adequate intake of amino acids.

Protein Intake. Vegetarians, in general, consume less total protein and even less animal protein than omnivores; however, studies consistently show they more than meet the recommended dietary allowances (RDA) and the recommended 10% of calories as protein. In addition, they more than meet the needs for the indispensable amino acids. Current evidence suggests that lower animal protein intake is beneficial and may lower urinary calcium excretion and slow the progression of renal disease. In addition, compared with animal protein, plant sources contribute less total fat, saturated fat, and cholesterol and more carbohydrate and fiber. In more restrictive diets, where variety or energy intake is limited, greater attention must be given to providing an adequate protein intake, especially in pregnant women, infants, growing children, and the elderly.

Hematologic Status

Iron

Nonheme iron from plant foods is less available than heme iron, and plant foods contain a variety of substances known to reduce iron availability; thus, the iron status of vegetarians is often questioned. However, plant foods also contain other substances that enhance iron uptake, and well-planned vegetarian

diets often contain more iron than omnivorous diets.

Some studies suggest that long-term LOVs, even with a higher fiber intake, maintain iron status no different from omnivores (14). Other studies, however, indicate vegetarians may have reduced iron stores, even though iron deficiency anemia as determined by hemoglobin levels is no more prevalent than among omnivores (15). However, although there was no significant difference in iron intake, a recent study found significantly lower hemoglobin levels in vegetarian children in England (15a). The authors suggested dietary advice was needed to ensure optimal absorption of iron. Another recent study found lower serum ferritin levels in both male and female vegetarians than in omnivorous controls, although the vegetarians consumed significantly more iron (16). Although lower iron stores increase risk of deficiency, the optimal storage level continues to be debated, particularly in view of evidence of an association between elevated iron stores and coronary heart disease.

The high levels of iron in well-planned vegetarian diets combined with the frequent intake of vitamin C-rich fruits and vegetables appear to protect against iron deficiency, which is more likely to be encountered among those on restrictive vegetarian diets, such as macrobiotic. Iron deficiency is also more prevalent in developing countries where dietary choices are limited and there is greater reliance on unleavened and unrefined cereal products (14).

Folate

Intake and blood levels of folate are often higher in vegetarians than omnivores because of their greater use of fruits and vegetables. Elevated folate is of concern in individuals whose vitamin B_{12} intake is low because folate may delay the appearance of megaloblastic anemia and thus mask a developing vitamin B_{12} deficiency with its potentially irreversible neurologic effects (17).

Vitamin B_{12}

Vitamin B_{12} is of particular interest because the usual dietary sources of this vitamin are animal products. Persons who include only plant foods in their diet, such as vegans, are at increased risk of deficiency unless care is taken to include a reliable source of vitamin B_{12}. Vitamin B_{12} deficiency can result in serious and irreversible neurologic and neuropsychiatnic abnormalities, and these potentially significant consequences necessitate giving attention to this vitamin in any discussion of vegetarian diets.

In addition, inactive analogues of this vitamin occur in foods and are found in the body. However, they are not differentiated in the usual microbiologic assays used to assess either vitamin B_{12} status or its content in foods, which are likely overestimated unless a method specific for cobalamin, the active form, is used (18).

Sources. Plants do not synthesize or store vitamin B_{12}. The ultimate source of this vitamin is microbial synthesis. Vitamin B_{12} occurs in plants only if they are contaminated by bacteria producing it (18). Such contamination is more likely where sanitary procedures are not followed in handling food and may be a reasonable explanation for the limited vitamin B_{12} deficiency occurring among vegan populations in developing countries. Animals either ingest the vitamin or absorb what is produced by bacteria in their intestines, thus becoming a source of vitamin B_{12} for those who consume animal products.

As noted, the microbiologic assays often used to assess vitamin B_{12} content determine the inactive vitamin B_{12} analogues, as well as cobalamin, the active form of the vitamin. Labels on many food products give values for the nonactive analogues rather than for cobalamin. This is misleading and causes confusion for tire consumer. Assays specific for cobalamin indicate that many food products commonly thought to be sources of vitamin B_{12} in actuality contain mostly inactive analogues (18); these include spirulina, tempeh, other fermented foods, and most sea algae. It was suggested that individuals relying on spirulina as a source of vitamin B_{12} might develop a deficiency more rapidly because some of the analogues contained in it actually block vitamin B_{12} metabolism (18).

Intake and Status. Serum vitamin B_{12} levels in vegans are generally lower than those in omnivores, with intermediate levels found in LOVs. Recently, individuals adopting a vegan diet showed a more rapid drop in serum vitamin B_{12} levels than anticipated, and those using vitamin B_{12} supplements or vitamin B_{12} fortified foods had higher mean serum levels over time (19). Similarly, serum vitamin B_{12} levels declined over a 2-year period in six of nine subjects adhering to a “living food diet” (20).

It is remarkable that there are so few reported cases of vitamin B_{12} deficiency even among vegans. Observations, however, suggest that suboptimal vitamin B_{12} status may occur well before the deficiency is discovered. Reasons for the low incidence of vitamin B_{12} deficiency include the very small requirement, relatively large stores, and a very efficient enterohepatic circulation that recovers most of the vitamin B_{12} excreted in the bile. Intestinal bacteria: produce vitamin B_{12}; however, most of this occurs below the ideal site for vitamin B_{12} absorption and it is excreted in the feces (18). Sonic evidence indicates that small amounts are produced in the small intestine; however, its unclear how much of this is the active form (18). Some vegans may consume the vitamin in foods eaten outside their homes. In developing countries, food and water contaminated

Nota: Todo complexo B, inclusive a B_{12} pode ser encontrada em abundância no levedo de cerveja, *Saccharomyces cerevisiae*, facilmente acessível no comércio.

with vitamin B_{12}-producing bacteria, in conjunction with poor hygienic practices, may contribute to vitamin B_{12} intake.

There is limited evidence that some seaweeds may contribute active vitamin B_{12}, presumably from contamination with plankton. Vegans consuming *Clorella* or *Nori* sea weed had serum vitamin B_{12} concentrations twice as high those not consuming these seaweeds (20). In another study, increased consumption of seaweeds by a mother led to a normalization of urinary methylmalonic acid (MMA) in her breast-fed infant (21). In contrast, ample consumption of seaweed by vitamin B_{12}-deficient infants did not improve their abnormal hematologic indexes and there was no relationship between algae consumption by macrobiotic adults and their vitamin B_{12} status (22, 23). Reliable sources of vitamin B_{12} must be ensured to prevent deficiency in individuals who consume no animal foods.

Other Nutrients

Calcium and Vitamin D

Adequate calcium and vitamin D intakes are important to ensure optimal bone status over the lifetime. Recent evidence suggests that calcium also may be important in regulating blood pressure and preventing colon cancer. Milk and dairy products supply 70% of calcium in U.S. diets, and questions regarding adequacy are often expressed when intake of these foods is limited, as in vegan diets.

Intake. Calcium intake among LOVs appears to be similar to that of omnivores, whereas vegans take in less. The long term impact of this lower intake on bone health is yet known, although some evidence warrants concern (14). In addition to the lower intake of calcium, vegans consume lower levels of vitamin D. The low consumption of vitamin D may be further exacerbated in some cases by limited exposure to sunlight. Low vitamin D concentrations and secondary hyperparathyroidism were documented during the winter in vegans living at north latitudes (25). Vitamin D deficiency was also documented in British Asian vegetarians and is a frequent concern among macrobiotic children (26, 27). The Institute of Medicine recently released new recommendations for intake of nutrients related to bone health (27a).

Factors Affecting Calcium Status. Besides vitamin D, a variety of other dietary factors also influences calcium status. A consistently lower intake of protein, as often seen among vegetarians, may decrease calcium requirements (28). Numerous studies demonstrate that increases in animal protein intake result in increased urinary calcium excretion. This relationship is not seen with plant protein (28). In addition, the ratio of dietary calcium to protein is thought to be important (29). This ratio in milk and dairy products is very favorable to a positive calcium balance (29). It is higher in LOVs than in omnivores and even higher than in vegans.

Similarly, a high intake of sodium increases calcium excretion (29a). There is some evidence that vegans consume less sodium than LOVs or omnivores. However, it was suggested that the characteristically increased consumption by vegans of oxalate- and phytate-containing may offset the benefits of their lower intake of protein and sodium (24).

Although lower rates of hip fracture are reported in populations worldwide with much less calcium intake than the United States where fracture rates are higher, genetic and lifestyle factors may play important roles. Optimal calcium intake under different dietary and lifestyle conditions remains to be determined.

Sources. Obtaining adequate calcium intake, as with all nutrients, depends on food choices. Individuals consuming relatively large amounts of animal protein, even though dairy products are not excluded, may need to give special attention to calcium intake. Vegans also may need to give attention to supplying an appropriate intake, especially during periods of growth. In general, few other foods provide as concentrated a calcium source as dairy products; however, it is relatively widely distributed among plant foods. The bioavailable calcium from various food sources has been calculated and may be useful in guiding food choices (24). The calcium in high-oxalate vegetables such as spinach, Swiss chard, and beet greens is largely unavailable; however, kale, broccoli, Chinese cabbage, and mustard and turnip greens provide substantial amounts of available calcium. Legumes and some nuts and seeds also contribute to calcium intake. Unfortified soy beverages provide negligible amounts, whereas calcium-set tofu and fortified soy milks are rich sources.

Zinc

Meat, fish, and poultry provide 40 to 45% of the zinc in the U.S. diet; dairy foods and grain products each contribute a little less than 20%. Nonetheless, reported zinc intake among vegetarians is similar to that of omnivores. However, its lesser availability from plant foods may result in somewhat lower zinc status among vegetarians than among nonvegetarians. A lower zinc intake was found among vegetarian children and adolescents, but it did not affect their growth; vegetarians were slightly taller than nonvegetarian controls (30). A recent study of adolescent female vegetarians found no difference in dietary zinc intake by LOVs, semivegetarians, or omnivores (31). Further, the investigators found no differences in mean values for any indicator of zinc statums among the groups. Nonetheless, 24% of LOVs, 33% of semivegetariarrs, and 18% of omnivores had low serum zinc levels. Attention should be given to ensuring an adequate intake of foods that supply this nutrient.

VEGETARIAN DIETS IN THE LIFE CYCLE

Risk of nutritional deficiencies is greatest during periods of growth and adequate intake of all nutrients should be ensured at these times. The impact of vegetarian diets on various stages of the life cycle was recently reviewed (6).

Pregnancy and Lactation

LOV diets provide adequate nutritional support during pregnancy and lactation, but special attention is needed to obtaining certain nutrients when following a vegan or macrobiotic diet. These include energy, iron, vitamin B_{12}, calcium, and vitamin D. Vegetarians are more likely to breast-feed their infants and to do so longer than the general population. This necessitates continued attention to dietary intake. Guidelines for counseling pregnant vegetarians also have broader application to other groups (32).

The few reports of pregnant vegetarians suggest a possible increased risk of earlier labor and lower birth weight in those following a more limited diet, although no difference in incidence of pregnancy complications was seen (33). More-concentrated energy sources may be necessary than are usually consumed on a vegan diet to ensure appropriate weight gain. Low serum ferritin levels are associated with increased risk of prematurity and low birth weight, and therefore care should be taken to ensure adequate iron intake for all pregnant women.

Normally, enough vitamin B_{12} is deposited in the fetus to last from 6 to 12 months after birth, yet a number of cases of vitamin B_{12} deficiency have been reported in infants of vegan mothers, with the deficiency frequently developing before 6 months of age (34, 34a, 34b). The infants were totally breast-fed by vegan mothers who showed no clinical signs of deficiency, although later testing confirmed they had low vitamin B_{12} status. Low maternal serum vitamin B_{12} levels were reflected in low values in milk (35). It is suggested that it is currently ingested vitamin B_{12} that is available for placental transport and secretion in the breast milk (36). Thus, totally breast-fed infants born to vegan mothers are at increased risk of vitamin B_{12} deficiency because of decreased stores at birth and low milk values.

Certain features are characteristic of infants developing a vitamin B_{12} deficiency: increased fretfulness and apathy, decreased socialization and activity, and regression in motor control. The infants are generally very small for their age and show serious neurologic deficits. Upon testing, the vitamin B_{12} deficiency is apparent. The usefulness of MRI (magnetic resonance imaging) in diagnosis and follow-up of patients with suspected diseases of myelination was recently emphasize (34a). In most cases there is rapid improvement with administration of vitamin B_{12}. Unfortunately, however, there appear to be long-term neurologic deficits in some cases (37). Vegan women must understand the importance of consuming a reliable source of vitamin B_{12}, at least during pregnancy and lactation, and it must be included in the diets of infants and children.

Low vitamin D status and low calcium intake were found in lactating macrobiotic women (35). In view of the increased calcium needs in pregnancy and lactation, this could result in maternal bone demineralization. Adequate calcium and vitamin D must be ensured at these critical stages of the life cycle.

Essential fatty acids and their derivatives play important roles in fetal development, especially of the retina and central nervous system, and parturition (33). Docosahexanoic acid (DHA, 22:6n-3), while found in fish, occurs in only small amounts in eggs and is absent from commonly consumed plant foods. In contrast to the low level of DHA, vegetarian diets contain high amounts of linoleic acid (18:2, n-6). DHA can be synthesized in the body from linolenic acid (18:3, n-3); however, high levels of linoleic acid inhibit this process.

In comparison to omnivores, a lower proportion of DHA was found in plasma and cord artery phospholipids, as well as in the milk of vegan mothers (33). As expected, the erythrocyte lipids of their infants contained a low proportion of DHA than those of infants breast-fed by omnivorous mothers or fed cow's milk formula. It was suggested that vegans use soybean or canola oils, which have a lower ratio of linoleic:linolenic acid, to facilitate the body's synthesis of DHA.

Infancy and Childhood

Concerns have been expressed regarding vegetarian diets for children whose vulnerability is great for nutrient deficiency, yet there is little evidence that physical or intellectual growth has been harmed (6). The growth of Seventh-day Adventist LOV children is the same as that of omnivores, with no greater evidence of nutritional deficiencies (30). While vegan children weighed less and were shorter than controls, their growth was within normal ranges and catch-up occurred by about age 10 (38). The lower growth appeared related to the high bulk and low energy density of some vegetarian diets combined with the small stomach capacity of young children. Recently, investigators reported significant catch-up in height and arm circumference for age in boys and girls combined who had followed a macrobiotic diet in early childhood. However, both boys and girls were still significantly below reference values for height, and girls were below reference weight-for-height and arm circumference for age (38a). Multiple regression analysis showed that inclusion of moderate amounts of dairy products improved growth of vegan children.

Inadequate weaning foods deficient in calories, vitamin D, calcium, iron, and vitamin B_{12} may be used by some vegan or macrobiotic parents, resulting in low growth and nutritional deficiencies. Similar diets continued into preschool years resulted in impaired growth, rickets, iron deficiency anemia, and vitamin B_{12} deficiency (39). Vegetarian food guides are available and can be helpful in planning diets for children and other age groups (40).

Adolescents

The few studies describing the nutritional status of vegetarian adolescents were recently reviewed, and suggestions were made for dietary management (41). Not everyone adopting a vegetarian diet understands the nutritional implications of excluding animal products, and care must be taken to ensure adequate intake, especially of vitamin B_{12}, calcium, and vitamin D, as well as iron and other trace elements.

Preadolescent LOV females were shorter than omnivores, but were taller than omnivores later in adolescence (30). This suggests a delay in the pubertal growth spurt. They were also reported to experience a 6-month delay in onset of menarche. These findings appear to represent a delay in physical maturation that maybe of benefit in adult life, particularly in relation to decreased risk of breast cancer (30). Recent investigations in Europe also found that vegetarian children grow at least as well as omnivorous children, and both were chose to the 50th percentiles for both height and weight (41a).

Compared with omnivores, LOV adolescents reported significantly greater intake of fruits, vegetables, and starchy foods and lower intake of dairy products, junk foods, and (as expected) meat (30). Thus, their dietary pattern more closely approximated current recommendations than that of the omnivorous controls. As noted previously, a larger proportion of LOVs and semivegetarians had low serum zinc levels than omnivores, although there was no difference in intake (31). Similarly, more LOVs and semivegetarians than omnivores had low iron stores. They were, however, more likely to consume greater amounts of antioxidants and other protective phytochemicals.

Adult and Elderly Vegetarians

Adults may adopt vegetarian diets to lose weight, to decrease risk of chronic disease, or as part of a therapeutic regimen to control disease. As noted, vegetarians, and especially vegans, generally weigh less and have lower serum cholesterol levels and lower blood pressure. If no animal products are included in the diet, attention is warranted for those nutrients noted above as at risk. Low vitamin D levels were reported in some elderly vegetarians as well as marginal iron and zinc status (6, 16, 42). Adequate vitamin D is particularly important in maintaining bone health in aging women and care must be taken to ensure adequate intake and/or exposure to sunshine.

Impaired absorption makes vitamin B_{12} deficiency increasingly common with advancing age in both vegetarians and omnivores. Possibly, vegetarians, if they have reduced stores, may be at risk for earlier manifestation of the deficiency. Further, vitamin B_{12} deficiency in the elderly is rarely accompanied by anemia or megalohlastosis and serum vitamin B_{12} levels in the elderly are often in the currently defined normal range (43). It was suggested that the cutoff for suspecting a vitamin B_{12} deficiency should be below 258 pmol/L (<350 pg/mL) rather below 148 pmol/L (<200 pg/mL). Because there is a limited window of time for effective intervention in a vitamin B_{12} deficiency, attention must be directed to the status this vitamin in elderly persons.

HEALTH IMPLICATIONS OF VEGETARIAN DIETARY PRACTICES

The association of vegetarian diets with lower risk for several chronic diseases is well documented, and various Studies investigating the relationships have been reviewed (10, 44). The standardized mortality ratio (SMR) for all-cause mortality is greatly reduced among vegetarians who are known to consume more fruits, vegetables, and polyunsaturated fatty acids and less saturated fatty acids, cholesterol, and alcohol than the general population (5-9, 44, 44a). They also smoke less, have a lower body mass index (BMI), and may exercise more.

The specific health-promoting factors associated with a vegetarian lifestyle continue to be investigated, with particular attention currently focused on phytochemicals and the foods that contain them. These nonnuntritive substances include a wide range of chemicals found in plant foods and are reviewed elsewhere (45, 45a). These substances can alter various hormone actions and metabolic paths in beneficial ways. The advantages of fruits and vegetables are so well accepted that recommendations to include more of them in the diet are heard with increasing frequency. Some of the positive health effects of vegetarian diets may be due to the increased intake of these foods.

Several major epidemiologic studies focus on Seventh-day Adventists, a conservative religious denomination. Adventists follow a broad range of dietary practices, from total vegetarian to usual American diets. Approximately half are vegetarians, with the great majority of these being LOVs. Certain lifestyle characteristics, such as smoking and alcohol consumption, which can confound or modify the effects of other factors, are largely absent from this population. The Adventist Health Study provides opportunity to compare vegetarian and omnivorous dietary practices within a population with great similarity of other lifestyle factors. Overall mortality rates are lower among Adventists than in the general population. Although they die of similar diseases, they appear to develop these diseases at a hater age (46).

Cancer

The German Vegetarian Study found death from all cancers in vegetarians was reduced by 52% in men and 26% in women compared with expectations (47). More specifically, the SMR for colon cancer was found to be 44 in men and 78 in women. Longer duration of vegetarian practices decreased risk of cancer mortality.

The risk of death from cancer is considerably lower among Adventists as a whole than in an appropriate reference population (48). Lower risk would be expected for those sites associated with cigarette

smoking or alcohol; however, the reduction in risk included nearly all major cancer sites, with a greater reduction for males than for females.

The relationships between dietary components and specific cancer sites were investigated in the Adventist population and recently reviewed (46). Multivariate analysis was used to control for factors other than the variable of interest.

Frequent consumption of fruit (>1/day vs. <3/week) was associated with a 75% reduction in risk of lung cancer, independent of past smoking status. The risk of stomach cancer was also greatly reduced in those who consumed fruit frequently. Raisins, dates, and other dried fruit provided significant protection against prostate cancer. Frequent consumption of tomatoes and dried beans also may protect against prostate cancer, while consumption of fish more than once a week may increase risk. No association with dietary factors, including animal fat, was found for breast cancer.

Striking protection against pancreatic cancer was afforded by frequent consumption of legumes, with those consuming dried beans and peas more than twice a week having only 1/30th the risk of those who consumed these foods rarely or not at all. An 80% reduction in risk of this cancer was associated with frequent consumption of raisins, dates, and other dried fruit.

Individuals who ate beans more than twice a week had a 42% lower risk of developing colon cancer than those who ate beans less than once a week. A similar reduction was seen in those who consumed more fiber. In contrast, a somewhat greater risk was associated with eating meat, fish, or fowl several times each week. After adjusting for age, sex, and smoking history, frequent consumption of beef was associated with a more than twofold increase in risk of bladder cancer.

These results suggest that, with the exception of bladder and perhaps colon cancer, dietary factors other than the absence of meat are the protective agents in the reduced risk of cancer seen among vegetarians (46). Others reported an inverse relationship between milk intake and incidence of breast cancer (49). Thus, increasing attention is being focused on foods commonly consumed by vegetarians and the protective compounds they contain.

Coronary Heart Disease

Lower risk of death from coronary heart disease (CHD) among vegetarian populations is well established and not surprising given their dietary and lifestyle characteristics resulting in lower body weight, lower blood pressure, and lower serum lipid levels (6-9). An LOV vegetarian diet in an African American population was also associated with a more favorable profile of blood lipid risk factors for premature CHD than the omnivorous diet (50). Multiple factors undoubtedly play roles in decreasing the risk seen among vegetarians.

An association of meat consumption and fatal ischemic heart disease was described in the Adventist Mortality Study, and more recently, data from the Adventist Health Study confirmed that relationship (51). Risk of fatal CHD was nearly twice as great in men who ate beef up to three times a week than in men who never ate any, and in men consuming beef three times a week or more, risk was more than twofold greater. Meat eating did not change the risk of CHD for women.

The same analysis revealed other intriguing relationships. The risk of both nonfatal and fatal CHD was lower in those who consumed mainly whole wheat bread than in those who ate mainly white bread (51). Similarly, the risk of both nonfatal and fatal CHD was lower in those who ate nuts frequently than in those who ate nuts less than once a week. The protective effect of frequent consumption of nuts was found consistently among various subgroups including both vegetarians and nonvegetarians.

A carefully controlled dietary trial was subsequently conducted to investigate these relationships further (52). Moderate quantities of walnuts were incorporated into a National Cholesterol Education Program Step 1 isocaloric diet in place of fatty foods, meat, and visible oils, while maintaining fat at 30%. This resulted in a more favorable lipoprotein profile. The possible mechanisms mediating the beneficial effect of nuts have been reviewed (53).

To date much of the research investigating the relationships between diet and CHD has focused on dietary factors related to modifying serum lipids. Rapid expansion over the last decade of our understanding of various plant constituents has led to rethinking the relationship of diet to heart disease (54). Whereas great emphasis was placed on dietary fat, it is now suggested that other factors, such as higher intake of antioxidants, may play important, if not deciding, roles. This is not to suggest fat intake should be ignored, but other factors should also receive attention.

Hypertension

Cross-sectional studies often report that vegetarians have lower blood pressure and lower incidence of hypertension than omnivores. This was also documented in African Americans, a population with a well-recognized increased risk of hypertension (50). Confirmed hypertension occurred in significantly fewer vegetarians than semi-vegetarians and omnivores. Mean systolic blood pressure was significantly lower in black vegetarians than in black nonvegetarians but was higher than in white vegetarian or nonvegetarians, suggesting that vegetarian dietary practices do not completely offset the risk of hypertension in the black population (50).

In contrast, the Health Food Shop Users cross-sectional study found no difference in blood pressure between vegetarians and omnivores (44). It was suggested that lifestyle factors other than avoidance of meat may be shared by vegetarians and other health conscious individuals and may affect blood pressure.

Randomized controlled trials introducing an LOV diet meat eaters were reviewed (55). The review indicated that the reported blood-pressure-lowering

effect of vegetarian diets is between 5 and 10 mm Hg in systolic blood pressure and is independent of effects of changes in body weight.

The relationships between vegetarian diets and decreased risk of hypertension are complex because of the myriad dietary and lifestyle components that interact in this, as in other, chronic diseases. None of the characteristics of the vegetarian diet alone - absence of meat, type protein, high polyunsaturated:saturated fat ratio, or high fiber, potassium, or magnesium intakes—has been identified as the active agent (56). The combined effect of several specific foods and/or nutrients may be responsible for the lower blood pressure seen in vegetarians.

Diabetes

Vegetarians may be at less risk for developing diabetes than omnivores. Among Adventist Health Study volunteers, vegetarians have lower rates of diabetes than omnivores. Nonvegetarian men, after adjusting for age and weight, were 1.8 times more likely to die from diabetes than vegetarian men. No difference, however, was seen among women (56). Further, an increased risk of diabetes appearing on the death certificate was seen with increased meat consumption in men, i.e., there was a dose response; in women, increased risk was seen only with meat consumption more than six times a week.

Various factors found among vegetarians have been suggested as protective for diabetes. Among these are lower body weight, lower serum cholesterol levels, high complex carbohydrate and fiber intake, and lower fat and animal protein intake. The benefits of high-carbohydrate, high-fiber diets in treating diabetes have been demonstrated (57).

Osteoporosis

Studies of bone mineral status in vegetarians and omnivores were reviewed (58). No differences were found in either cortical or trabecular bone in recent studies. However, an earlier report suggested postmenopausal vegetarian women were protected against bone loss and that their lower protein intake might be a major beneficial factor (58). A recent prospective study reported a small but significant increase in risk of forearm fracture for women who consumed more than 95 g/day of total protein, compared with those who consumed less than 68 g (59). A similar increase in risk was seen for animal protein, but no association was found with vegetable protein. Those who ate five or more servings per week of red meat had a higher risk of forearm fracture than those eating fewer than one serving a week.

Concern was expressed about the bone status of vegans (24). Recent reports lend support to that concern, although to date there are few studies specifically of vegans. Obese postmenopausal omnivorous subjects placed on a low-calorie, high-fiber diet for 6 months lost significantly more bone from the lumbar spine than nondieting obese controls (60). Whether the loss of bone was due to the loss in weight, dietary factors, or a combination is not own. However, the fiber, calcium, and protein intakes reported in this study would not be uncommon among vegans Since leanness is also a risk factor for osteoporosis and since vegans are often leaner than the general population it would be wise to give attention to their bone status. Investigators recently reported a higher risk of exceeding the lumbar spine fracture threshold and of being classified as osteopenic in vegan than in lactovegetarian postmenopausal Taiwanese women (60a). Others reported significantly lower bone mass at several sites in Dutch adolescents who had followed a vegan macrobiotic diet in childhood (60b).

Bone density was compared with dietary intake in five counties in China with widely differing calcium intakes (61). Bone density was approximately 20% higher from the fourth to well into the eighth decade of life in areas where dairy products were consumed (Ca intake 724 mg/day) compared with those where dairy products were not used (Ca intake 230—359 mg/day). Protein intake in the former was 75 g/day versus 49 to 57 g/day in the latter counties. The lower protein intake reported in these Chinese did not confer protection against low bone density when the calcium intake was very low.

The dietary and lifestyle factors related to risk of osteoporosis have been reviewed (62). Many factors other than calcium affect bone status and risk of fractures; however, a consistently low calcium intake combined with low vitamin D status and high fiber intake may place vegans at greater risk for low bone density. On the other hand, their lower

protein intake, and common consumption of soy foods that contribute phytoestrogens may be protective. Studies are needed to clarify these issues.

PHYSIOLOGIC RESPONSE TO VEGETARIAN DIETS

Metabolic Rate

The reduced risk of disease found among vegetarians suggests biologic processes are influenced by the diet. Vegetarians generally weigh less and have less body fat than omnivores. However, the exact reason for the differences remains to be resolved. Possibilities include lower total energy consumption or differences in resting metabolic rate (RMR) and the thermic effect of a meal (TEM) that could ultimately affect energy expenditure. High fiber intake and meditation, both possibly observed more frequently among vegetarians, appear to decrease postprandial thermogenesis, a finding that would not, however, contribute to the lower weight in vegetarians (63, 64). Vegetarians had a higher RMR than nonvegetarians, as well as a higher plasma norepinephrine concentration and a faster rate of norepinephrine appearance (65). The investigators concluded that macronutrient composition and plasma norepinephrine may be independent modulators of RMR, but the effect appears to be small.

The Colonic Milieu

Lower cancer incidence among vegetarians has led investigators to study various factors thought to be related to particular cancers. Some, but not all, reports suggest vegetarians have a lower concentration of total bile acids in their stools than nonvegetarians. A recent investigation found no difference in bile acid concentration in total feces of vegetarians and omnivores, but the vegetarians did have a lower concentration in fecal water (66). The latter may be of greater significance, because it is the fecal water that is in contact with the colonic mucosa. Further, vegetarians had a higher ratio of primary to secondary bile acids and a lower concentration of deoxycholic acid in fecal water. These findings are similar to those of other studies comparing populations at low and high risk of colon cancer. Deoxycholic acid is thought to be a promoting factor for colon cancer, and its concentration appears to be influenced by dietary saturated fat (66). Vegetarians also have higher wet fecal weight and a higher defecation frequency. In addition, a significant decrease in mutagenic activity in urine and feces was recently reported after shifting from an omnivorous to a lactovegetarian diet (66a). Similarly, switching from a diet rich in fat and meat and poor in dietary fiber to a vegetarian diet poor in fat and rich in dietary fiber resulted in a marked decrease in formation of hydroxyl radicals in the feces (66b). All of these factors may contribute to the lower frequency of colon cancer found among vegetarians.

Colonic epithelial cell proliferation was investigated in populations at differing risk for colon cancer. Compared with omnivores, vegetarians had a lower rate of cell proliferation (67). The possible association between cell proliferation and various dietary factors was investigated in healthy vegetarians and omnivores (68). Increased intake of calcium appeared to be associated with a reduced rate of cell proliferation, although not all studies agree.

Hormonal Effects

The relationship between dietary fat intake and breast cancer has prompted numerous studies, some among vegetarians, many looking at various hormonal associations. Results of studies investigating menstrual differences among vegetarians are inconclusive, with some showing more ovulatory disturbances and some reporting less (69). These differences are likely due to different study designs. Some were of short duration; dietary components including fat, fiber, and carbohydrate differed; and the definition of vegetarian was not consistent.

An inverse relationship between dehydroepiandrosterone sulfate (DHS) and breast cancer has been suggested in premenopausal women. A study of adolescents found higher DHS levels in vegetarians than in omnivores (70). However, no association was found with any nutrient, and caution was urged until more definitive data are available.

The biologic effects of soy protein, a common ingredient in vegetarian diets, were investigated in premenopausal women (71). The menstrual changes found in response to the inclusion of soy protein may be beneficial with respect to risk of breast cancer and may help to explain the lower risk in populations who consume significant amounts of soy.

Antioxidant Status

Much attention is currently focused on the benefits of dietary antioxidants. It is not surprising that vegetarians, in view of their diet, are reported to have higher blood levels of β-carotene, vitamin C, and vitamin E, nutrients thought to play important roles in the prevention of chronic disease (72).

The various modifications to the physiologic milieu will continue to be investigated as reasons are sought for the beneficial effects of vegetarian diets.

VEGETARIAN DIETS IN THE TREATMENT OF DISEASE

Vegetarian diets have been proposed, and used, as treatment for various disease conditions. Macrobiotic diets are claimed to be helpful in treatment of serious disease; however, evidence supporting the claims is limited (6).

Coronary Heart Disease

A number of clinical trials have investigated diet and lifestyle changes in the treatment of coronary heart disease, with or without drug intervention. Regression of atherosclerosis has now been shown in patients with advanced disease in multiple studies, which were recently reviewed (73). Generally, the diets used were similar to vegetarian diets, viz., low in fat, saturated fat, and cholesterol, and high in fiber. Lifestyle factors were often incorporated in the treatment and included exercise and stress management. Recently, a very low fat, vegetarian diet was used as part of a comprehensive treatment approach. Quantitative coronary angiography demonstrated regression of atherosclerosis in subjects after a year, but progression in controls (74). Frequency, duration, and severity of angina were reduced in subjects, while controls experienced increases. Just as vegetarian diets appear to provide primary prevention against coronary heart disease, they also contribute to secondary prevention and the reversal of CHD.

Diabetes

A vegetarian diet may be helpful in managing diabetes. Current recommendations for diabetics include reducing total fat, saturated fat, and cholesterol, as well as increasing fiber intake. This may result in a food pattern similar to a vegetarian diet, especially if significant sources of plant proteins are included. Because diabetics are prone to diabetic nephropathy, this may be particularly appropriate. Evidence from insulin-dependent diabetics suggests that isocaloric substitution of vegetable for animal protein results in beneficial effects on renal function

(75).

Low-fat, high-fiber diets effectively reduced serum glucose and cholesterol levels in diabetics (57). In addition, such diets may help control weight. Thus, evidence indicates that vegetarian diets are not only compatible with therapeutic diabetic regimens but may be beneficial in controlling the metabolic aberrations associated with diabetes. The Diabetes Care and Education Dietetic Practice Group of the American Dietetic Association recently published a comprehensive resource for diabetes management in vegetarians (75a).

Renal Disease

The importance of protein in the management of renal disease is recognized. Although a low-protein intake is desirable, the use of vegetarian diets is often questioned because of their high phosphorus content relative to the quality and quantity of protein they contain. However, a recent review of the impact of vegetarian diets on renal disease provides evidence from both animal and human studies of potential benefits from such diets (76).

Plant proteins exert significantly different renal effects from animal proteins; the effects seem comparable to those achieved by reducing the total amount of dietary protein. In subtotally nephrectomized rats, soy protein resulted in less proteinuria, reduced glomerular filtration rate, milder renal histologic damage, and longer survival than casein. In patients with diabetic nephropathy, an LOV diet that provided 1 g protein/kg/day reduced proteinuria while maintaining good nutritional status over 8 weeks. In addition, plant-based diets exert beneficial effects on the hyperlipidemias associated with renal disease, and soy-based diets reduce serum cholesterol independent of dietary fat (76). A carefully designed vegan diet used successfully to manage mild chronic renal failure may be the diet of choice when the conventional low-protein diet is poorly tolerated (76a).

Because plant foods provide more nonessential amino acids than do animal proteins, they generate more urea. Consequently, it may be more difficult to minimize uremic toxicity on a strictly plant-based diet in severe chronic renal insufficiency (76). Fewer problems will be encountered on an LOV diet. In addition, a vegetarian diet may require an increase in phosphate binders in end-stage renal disease or dialysis, and attention should be directed using lower potassium fruits, vegetables, and grains to compensate for the higher potassium content of some legumes, nuts, and seeds. Guidelines for planning a vegetarian renal diet are available (77).

Other Conditions

Rheumatoid Arthritis

Claims are frequently made that special diets, including vegan or LOV diets, can alleviate the symptoms of rheumatoid arthritis. A recent review suggested this is part of “the lore of the disease” (78). Although a number of studies have been reported, most were poorly designed, did include controls, and were not adequately blinded. Often the subjects held a strong belief in the intervention.

Clinically demonstrable improvements rather than subjective responses were not always used. Nonetheless, some patients may benefit from a vegetarian diet (79).

Cancer

Claims continue to abound that a macrobiotic diet can cure cancer. Unfortunately, there is little supportive scientific evidence; however, recent reports suggest survival may be greater in some cases (80). Considerable concern exists that individuals may delay appropriate treatment for their disease and that the diet may contribute to malnutrition and weight loss (81).

COUNSELING ISSUES AND DIETARY GUIDELINES

Careful investigation of the dietary practices of individuals calling themselves vegetarians is essential for the health professional to provide optimal counseling, and general lifestyle practices that may affect health should be evaluated as well. The beliefs and attitudes that support these practices may affect a patient’s willingness to follow suggestions. Those adhering to more restrictive dietary practices, such as macrobiotics, may be less willing to seek or follow the advice of health care professionals. The attitude of the health professional will be perceived quickly, and a nonjudgmental approach is of utmost importance in establishing a productive relationship.

Issues to be considered in counseling pregnant vegetarians are described above and are applicable to others as well (32). Vegetarian food guides are available, as are specific applications for vegetarian adolescents (40, 41). Food sources for the nutrients most likely at risk are included in these guides. Bioavailable sources of calcium are also described (24). A vegetarian diet manual is available for use in various clinical conditions (82).

The basic principles for planning a vegetarian diet are the same as those for planning any other diet, with variety a key component. A diet restricted in either variety or amount can limit the intake of essential nutrients. Energy intake to maintain appropriate weight must be considered. Obtaining adequate calories may be a challenge on a vegan or macrobiotic diet, while avoiding excess calories may be equally challenging on an LOV diet that relies on full-fat dairy products (40). An emphasis is appropriately placed on unrefined foods in any diet.

There are many different ways to obtain the essential nutrients, and the health care provider should be aware of alternate sources for those nutrients commonly supplied by foods excluded from a given diet. A registered dietitian can be very helpful in providing guidance, information, and counsel. An adaptable, creative, and sensitive approach will be

most successful in providing dietary suggestions for individuals whose dietary patterns and beliefs differ from our own.

CONCLUSION

Current dietary recommendations call for increased consumption of plant foods in all diets. Evidence from populations consuming plant-based diets supports these recommendations. As one researcher said, "vegetables and fruits... are chemical powerhouses that produce dozens if not hundreds of unique and complex organic compounds, many of which are biologically active" (54). The potential health benefits, as well as issues of concern regarding vegetarian diets, have been described. The health professional has a responsibility to be informed regarding both, to encourage those dietary and lifestyle practices that promote health, and to provide alternatives to those that may be detrimental.

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