THE EFFECTS OF VEGETARIAN DIET ON THE CARDIOVASCULAR SYSTEM

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ABSTRACT

Vegetarianism is the refusal to eat meat and its products for various reasons. Furthermore, veganism is against eating and using all products derived from animals. Numerous studies have stated that plant-based nutrition reduces the risk of cardiovascular system diseases, but also cannot supply the requirement of some vitamins and minerals. Although a vegetarian diet may decrease the risk of cardiovascular diseases, the findings of the studies related to the low intake of protein, vitamins, or minerals should be taken into account in terms of harmful effects. In this review, the studies have been reviewed about the effects of plant-based nutrition on the human cardiovascular system. ***Keywords:*** Cardiovascular system, vegans, vegetarians, diet, plant proteins

INTRODUCTION

Vegetarianism is the refusal to eat meat (red meat, poultry, seafood, and the flesh of any other animal) (1). Vegetarians may be further sub-classified as vegans, pesco-vegetarians, lacto-vegetarians, lacto-ovo-vegetarians, and semi-vegetarians (2). Vegans avoid using or eating any animal products (2). Pesco-vegetarians consume fish and other seafood (2). Lacto-vegetarians eat dairy products; lacto-ovo-vegetarians eat dairy products and eggs (2). As another subgroup, semi-vegetarians usually follow a vegetarian diet but occasionally consume meat (2).

Some people think that consuming meat is unhealthy and that a vegetarian diet generally prevents diseases (3). Other common reasons for choosing vegetarian diets are animal welfare or rights, satisfying religious or spiritual needs, and saving the environment (3). The prevalence of vegetarianism varies around the world; roughly 5% of Americans, 8% of Canadians, 4.3% of Germans, and 30% of Indians follow a vegetarian diet (4-8). Vegan diet prevalence has been reported as 2% in the United States and less than 1% in Germany (4, 9).

Plant-based diets have documented health advantages (10). It decreases the serum cholesterol levels, blood pressure, and vegetarians have decreased cardiometabolic risk than omnivores (10). Vegetable and fruit intake frequency is inversely proportional to cardiovascular disease mortality, ischemic heart disease (IHD) mortality, stroke incidence, and stroke mortality (11). According to the studies, vegetarian diets decrease blood pressure compared to omnivorous diets (12). Lower blood pressure leads to a decrease in deaths from all causes, deaths from coronary heart disease (CHD), and stroke (12, 13).

In this review, the effects of deficiencies of some vitamins and minerals, effects of vegetarian diet on the cardiovascular system, possible effects of vegetarian diet on cardiac diseases, as well as the effects of soy protein, which is consumed by vegetarians, on heart function are investigated.

NUTRIENT PROFILES AND NUTRITIONAL DEFICIENCY OF VEGETARIANS

It is considered that vegetarian diets improve health and decrease the risk of cardiovascular diseases (CVDs) (14). On the other hand, a vegetarian diet may cause vitamin deficiency because vegetarians have lower intakes of protein, saturated fat, cholesterol, vitamin B12, vitamin D, zinc, calcium, and selenium (14).

Although veganism and vegetarianism exist all over the world, only in the past 50 years it was noticed that vegan and/or vegetarian diets lead to vitamin B12 deficiency (15). Vegans and vegetarians tend to have a vitamin B12 deficiency because their diets have a very low B12 content (15). Vitamin B12 can only be synthesized in nature by some bacteria found in the bowels of humans, therefore humans must provide the intake of vitamin B12 from their diet (15). Non-vegetarians receive vitamin B12 from meat, eggs, milk, and dairy products (15). Plant fertilization with manure might cause contamination with vitamin B12 synthesizing bacteria. Thus, organic vegetables can be a better source of vitamin B12 (15).

In a large-scale study, participants were stratified into non-vegetarian, semi-vegetarian, pesco-vegetarian, and strict vegetarian (16). Data on dietary patterns were collected, and nutrient profiles were presented. Results showed that pesco-vegetarians and non-vegetarians had the highest intakes of vitamin B12 and vitamin D while strict vegetarians had the lowest (16). Furthermore, intakes of calcium and iron were lowest in strict vegetarians (16). Conversely, strict vegetarians had the highest intakes of folate, soy protein, fiber, vitamin C, and vitamin E (16).

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Homocysteine is an amino acid that is produced through the demethylation of methionine and animal proteins contain plenty of methionine (17). It has been revealed that plasma homocysteine concentration is one of the independent risk factors of CHD (18). Vitamin B12 and some other B vitamins are necessary for homocysteine metabolism (19). Cobalamin (B12) as cofactor and folate (B9) as co-substrate are responsible for the remethylation of homocysteine (19). The other route for homocysteine metabolism is transsulfuration and it is a process that is dependent on vitamin B6 (20). Deficiency in these vitamins may result in the increment of plasma homocysteine concentration (21). Riboflavin (B2) has a role in the metabolism of other B vitamins and because of its role, riboflavin deficiency may affect homocysteine levels (22).

In a previous study, subjects were separated into groups such as vegetarians and non-vegetarians (21). Daily nutrient intakes' data was recorded and plasma homocysteine, vitamin B12, and folate levels were measured by obtaining fasting venous blood samples (21). The results of this study showed that vegetarian subjects had significantly higher mean plasma homocysteine concentration but lower vitamin B12 intakes than non-vegetarians (21). In addition, a positive correlation has been shown between animal protein intake and plasma homocysteine level in the non-vegetarian group (21).

VEGETARIANISM AND CARDIOVASCULAR DISEASES

Cardiovascular diseases refer to diseases of the heart and blood vessels (23). High intake of fat, saturated fats, and carbohydrates are important risk factors that increase the prevalence of CVDs (24). CVD is a medical term that includes diseases such as coronary heart disease (CHD), peripheral artery disease, cerebrovascular disease, rheumatic and congenital heart diseases, and venous thromboembolism CVDs are the major factor of global deaths (25, 26). It is responsible for one in four deaths across the world (26). The high prevalence of heart diseases was associated with lifestyle factors such as smoking, consuming refined foods, high animal fat content in the diet, and physical inactivity (27). According to a study, vegetarians have a 32% lower risk of getting CHD collated to non-vegetarians (28).

Diets containing high amounts of refined carbohydrates increase triglyceride concentration, while diets with a high fiber ratio decrease it (29). Dietary cholesterol is strongly associated with CVDs (29). The vegan diet has a cholesterol-lowering effect due to its low saturated fat content, soluble fiber, and other plant components (29). However, according to the findings of a previous study, although the total and low-density lipoprotein (LDL) cholesterol of vegans were at normal levels, high-density lipoprotein cholesterol level was low, homocysteine was high, and lipoprotein (a) level was negative in terms of coronary artery disease (CAD) (30). On the other hand, there are different opinions in studies about the effects of hyperhomocysteinemia (28-30). To understand the connection between hyperhomocysteinema and the vegan diet, the number of studies on this subject should be increased.

Atrial fibrillation has the highest prevalence in arrhythmias, and its risk factors include hypertension, CAD, and obesity (31). Plant-based nutrition reduces the likelihood of these risk factors. Improved vasodilatation, increased potassium intake, decreased blood viscosity are the main effects of plant-based diets for preventing hypertension (31). CAD is described as the blockage of the vessels that carry oxygen and nutrients to the heart (32). High-sensitivity C-reactive protein (hsCRP) is used as a marker of CAD (33). A high hsCRP level is an indicator of CAD risk (33). A study conducted with CAD patients with high hsCRP values showed that in addition to medical treatment, a vegan diet had lowered hsCRP levels (33). A vegan diet supports weight loss, glycemic control, and normalizing lipid values (33). However, studies examining medical treatment and diet together on CAD are limited (33). On the other hand, B12 deficiency is common among vegans and vegetarians (34). B12 deficiency may cause impaired carotid intima-media thickness and brachial flow-mediated endothelium-dependent dilation values compared to a similar group (34).

Vegetarian diets may not seem to be preventative for diseases, although it supports the treatment of type 2 diabetes (35). It is known that vegetarian diets combined with exercise can reduce the use of glucose in the body. Thus, plasma glucose levels and the use of glucoregulatory drugs decrease (34-36). A vegetarian diet also has beneficial effects without exercise. It reduces body weight and lowers blood lipids. Vegetarian diets are found more effective in glycemic control and treatment of type 2 diabetes compared to traditional diets (37, 38).

Trimethylamine N-oxide (TMAO) has been recently thought to be a prognostic marker for developing CVDs and most of the studies focus on this metabolite (39). TMAO is the form of trimethylamine (TMA) transformed by flavin monooxygenase in the liver (39). TMA is produced from substances such as choline, L-carnitine, betaine, and trimethyl lysine in the intestine (39). TMAO is a chemical compound that can accumulate in organs such as the heart and kidney (40). TMAO and its precursors are animal food items that originate mostly from fish, meat, egg, poultry, and milk (40). The amount of TMAO component is less in vegetarians because their diet contains fewer animal foods and these precursors (41). Preclinical studies showed that TMAO directly causes damage to the heart muscle and mitochondria (40). TMAO increases the risk of thrombosis and ischemic heart failure (HF) (40). In addition, studies indicate that a vegetarian diet avoids and cures HF (42).

In a meta-analysis by Miller et al. (43), it was observed that intake of egg yolks with diet increased urine and plasma TMAO concentrations. This study showed phosphatidylcholine, which is a type of choline in eggs, transforms TMA contrary to what is believed (43). These concentrations reach the highest level with consumption of 4-6 eggs (43). But they could not demonstrate a connection with increased TMAO levels and CVDs (43).

All dairy products, eggs, red meat, and processed meat include saturated fatty acids (44). In a randomized controlled study, it was revealed that plasma LDL cholesterol levels were raised by saturated fatty acids intake (44). Recent studies showed that a low-calorie vegetarian diet decreases LDL cholesterol levels and is efficient in preventing and treating cardiovascular system diseases (45). Conversely, cheese, eggs, and yogurt were linked to significantly lower IHD risk. Poultry, milk, and fish were not related to IHD (46). In a study carried out by Key et al. (46), it has been observed that when red meat and processed meat were consumed together, heart rate and IHD risk increased (46). Consumption of eggs reduces IHD risk in men but does not affect women (46). Yogurt and cheese were invertedly linked to IHD risk, but this relation was not significant in the study (46). Fatty acids and calcium in cheese generate insoluble soaps. It is thought that when saturated fatty acid absorption decreases, calcium binds to bile acids and diminishes enterohepatic circulation and cholesterol levels (44).

Vegetarianism is also preferred in different age groups and periods. It should be taken into consideration that nutritional needs vary depending on different periods of life and physical activity. If vegetarian people do not follow a proper diet it may have unfavorable health effects. In the studies with vegan and non-vegan athletes, there is no difference found in their performances (47). It has been observed that vegan athletes do not show any deficiency

compared to non-vegan athletes when they follow a suitable diet (47). A vegan athlete's relative wall thickness, as well as systolic and diastolic functions, are better than a non-vegan athlete's (47). Besides, a vegan athlete's end-diastolic volume and end-systolic volume are higher and stroke volume is lower than a non-vegan athlete. Measurable differences have not been seen between the muscle mass and bone density of vegan and non-vegan athletes (47). Vegan athletes have better cholesterol levels than non-vegan ones (48).

SOY PROTEIN CONSUMPTION AND CARDIOVASCULAR EFFECTS

Soy protein is a food frequently consumed by vegetarians rather than omnivores. The United States Food and Drug Administration authorized labeling of soy protein foods as reducing the risk of CVDs (49). However, it has not been definitively proven whether cholesterol efflux and macrovascular function can be changed with diets that are rich in polyphenols (50).

Soybeans contain many bioactive substances, including polyphenols and isoflavones (51). Flavonoids are grouped according to their chemical structure. These are: flavonols (quercetin, kaempferol), flavanols (catechins), flavones (apigenin), and isoflavones (daidzein, genistein) (51).

Many studies have observed that soy isoflavones reduce LDL levels, which has an important role in atherosclerosis pathogenesis (48, 52, 53). It has been found that blood cholesterol levels increase in many animals fed with animal protein diets (54, 55). Contrary, it has been demonstrated that using soy protein instead of animal protein causes hypercholesterolemia (48). In the studies on isoflavones, the bioactive molecule of soy, soy isoflavones caused arterial vasodilation and lower serum cholesterol in animals, and inhibit atherosclerosis in postmenopausal monkeys (56, 57). Some previous studies have been conducted to separate the protein effect from the isoflavone effect (53, 58-63). LDL cholesterol was reduced in two of these studies. It has been shown that protein influences LDL reduction and isoflavones have no effect (52, 63).

Cardiac complications due to radiotherapy include subacute or chronic CAD, congestive heart failure, ischemia, and myocardial infarction (64, 65). It is not enough to try to prevent interstitial fibrosis, inflammation of the myocardium, and thrombotic changes with anti-inflammatory and antithrombotic drugs (66). The inhibition of these radiation-induced damages with soy isoflavones has been proved histologically. It has been demonstrated that smooth muscle cell damage is reduced in the cardiac arteries of animals treated with radiotherapy and soy isoflavones (67). Soy isoflavones can be used as a complement to improve overall survival in patients surviving cancer with radiotherapy (67).

A prospective cohort study of Chinese women included nearly all soy foods - tofu, fried tofu, and tofu cakes. (68) The risk of cardiovascular disease, adjusted for age and energy, was reduced with soy protein intake (68). The elderly who consumed higher amounts of soy protein had a history of hypertension and a high body mass index. Women who consumed large amounts of soy protein had a lower risk of cardiovascular disease and a lower non-fatal myocardial infarction than women who consumed small amounts (68).

CONCLUSION

Studies in literature have generally shown that vegetarians have a lower risk of CVDs. Vegetarian diets contain low intakes of saturated fat and cholesterol. The consumption of food of animal origin is shown as a restrictive factor for choline, L-carnitine, betaine, trimethyl lysine levels. Therefore, the cardiovascular disease precursor TMAO is produced much less in the body. In addition, soy, which is consumed largely in vegetarian diets, is important for reducing the risk of CVDs. However, vegetarian diets can cause vitamin and mineral deficiencies since the diet does not contain animal products. Vitamin B deficiencies are especially important because vitamin B is responsible for homocysteine metabolism, and that plasma homocysteine concentration is one of the independent risk factors of CHD. For these reasons, it is important to regulate vegetarian diets by considering daily nutritional needs.

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