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## The Impact of a Vegetarian Diet on the Cardiovascular System

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**Abstract:** The vegetarian diet is gaining increasing popularity worldwide, particularly in developed countries. This phenomenon is driven by various factors, such as concern for animal welfare, growing social awareness about health, and the role of nutrition in maintaining it. Cardiovascular diseases have been the leading cause of death globally for many years, with many risk factors - including diet - being potentially modifiable causes. A vegetarian diet can support the treatment and prevention of cardiovascular diseases. According to the latest available knowledge, it has a particularly beneficial effect on lowering blood pressure, reducing the risk of developing coronary artery disease, and preventing metabolic syndrome. However, exclusively following this diet requires the inclusion of nutritional supplements to address potential deficiencies, preventing the development of other health issues.

**Streszczenie**

Dieta wegetariańska zyskuje coraz większą popularność na świecie, szczególnie w krajach rozwiniętych. Zjawisko to wynika z różnych czynników, takich jak troska o dobrostan zwierząt, rosnąca świadomość społeczna na temat zdrowia oraz roli odżywiania w jego utrzymaniu. Choroby układu krążenia od wielu lat pozostają główną przyczyną zgonów na świecie, a wiele czynników ryzyka - w tym dieta - należy do przyczyn potencjalnie odwracalnych. Dieta wegetariańska może wspierać leczenie oraz prewencję chorób sercowo-naczyniowych. Zgodnie z najnowszą dostępną wiedzą, dieta ta wykazuje szczególnie korzystny wpływ na obniżenie ciśnienia tętniczego, zmniejszenie ryzyka rozwoju choroby niedokrwiennej serca oraz zespołu metabolicznego. Niemniej jednak, stosowanie wyłącznie tej diety wymaga uwzględnienia suplementacji składników odżywczych, które mogą występować w niej w niedoborach, aby zapobiec rozwojowi innych schorzeń.

**The aim of the study:** The aim of this review is to analyze the current state of knowledge regarding the vegetarian diet and its impact on the body, with particular emphasis on the cardiovascular system. The analysis is based on articles available in PubMed and Google Scholar databases.

**Keywords:** vegetarian diet, cardiovascular system, hypertension, ischemic heart disease

## **Introduction**

Vegetarians are individuals who exclude meat, including fish, seafood, and products containing them, from their diet [1]. There are various forms of vegetarianism, differing in the degree of dietary restrictions. The most restrictive group is vegans, who completely eliminate all animal-derived products from their diet, including dairy, eggs, and honey. Lacto-vegetarians include only dairy products, while ovo-lacto vegetarians, the least restrictive group, incorporate both dairy and eggs into their diet [1,2]. Overall, a vegetarian diet is characterized by low levels of saturated fats and cholesterol, as well as a high fiber content. This is achieved through a higher intake of vegetables, fruits, whole grains, legumes, and nuts [3]. There are approximately 1.5 billion vegetarians worldwide, divided into two groups: "vegetarians by necessity," for whom meat is difficult to access, and "vegetarians by choice," who consciously abstain from consuming it. Studies show that between 5% and 10% of the global population belongs to the latter group, following some form of a vegetarian diet [4]. Cardiovascular diseases (CVD) are one of the leading causes of death worldwide and represent a major global health issue. This term encompasses conditions related to the heart and blood vessels [5]. In 2016, cardiovascular diseases accounted for nearly one-third of all deaths worldwide, and the number of deaths due to CVD increased by 42.4% between 1990 and 2015. Projections indicate that by 2030, these diseases could be responsible for over 23 million deaths annually [6]. The risk factors for the development of cardiovascular diseases encompass a range of complex elements, such as hypertension, dyslipidemia, hyperglycemia, obesity, unhealthy dietary habits, lack of physical activity, as well as differences related to gender, ethnicity, and genetic predisposition. Coexisting conditions, such as kidney dysfunction, thrombosis, and the negative effects of smoking, are also of significant importance. Given the broad spectrum of these factors, a vegetarian diet can be a valuable component in the prevention and treatment of cardiovascular diseases [7,8].

## **Vegetarian diet and its impact on hypertension**

Hypertension is a major risk factor for diseases such as stroke and coronary artery disease [9]. In the 1970s, intensive efforts were made to lower blood pressure when studies showed that treating hypertension reduced the risk of the aforementioned diseases. The introduction of the DASH diet, rich in fruits, vegetables, and low-fat dairy products, demonstrated positive effects in lowering blood pressure. Subsequent research suggests that a plant-based diet and reduced meat consumption also contribute to a decreased risk of hypertension, especially in young adults [10]. According to the WHO definition, hypertension is present when systolic blood pressure (SBP) is at least 140 mmHg and diastolic blood pressure (DBP) reaches 90 mmHg or higher. The number of adults suffering from hypertension has approximately doubled over the past 40 years, due to the aging population, an increase in the number of people, as well as changes in lifestyle and health habits [11]. In European countries, over 150 million people suffer from hypertension. The prevalence among adults is around 30%-45%, and in the group of individuals over 60 years of age, this figure exceeds 60% [12].

Based on the updated meta-analysis from 2023 conducted by Madsen H et al., it can be concluded that higher consumption of fruits and vegetables may reduce the risk of hypertension by approximately 9–11%. A beneficial effect was observed both with the combined intake of fruits and vegetables as well as with fruit alone, although the effect for vegetables was weaker. The risk of hypertension decreased by 11% with the consumption of 800 g of fruits and vegetables daily compared to 40 g, and by 19% with the consumption of 550 g of fruit daily. It was observed that the main impact on lowering blood pressure occurs with diets containing fruits such as apples, pears, blueberries, and grapes. The reduced risk of hypertension associated with the consumption of fruits and vegetables can be explained by various mechanisms, both direct and indirect, including effects on body weight. Fruits and vegetables provide vitamins C and E, folic acid, fiber, and potassium, all of which support blood pressure regulation. Fiber positively affects the endothelial cells of blood vessels, cholesterol levels, and insulin sensitivity, which reduces insulin resistance - a risk factor for hypertension. Potassium, in turn, lowers blood pressure by promoting vasodilation and improving endothelial function. A deficiency of this mineral reduces the potassium/sodium ratio, leading to decreased production of nitric oxide (a compound that dilates blood vessels), which ultimately results in increased blood pressure. Antioxidants in fruits and vegetables, such as vitamins C and E, reduce oxidative stress, which contributes to atherosclerosis and hypertension. Folic acid positively influences the cardiovascular system, which may also help in lowering blood pressure. Regular consumption of fruits and vegetables supports weight control, which further reduces the risk of hypertension [13].

Analyzing the 2020 meta-analysis by Lee KW et al. regarding the impact of a vegetarian diet on blood pressure, it can be concluded that a vegetarian diet significantly lowers both systolic and diastolic blood pressure, by -2.655 mmHg and -1.687 mmHg, respectively. These results are consistent with earlier studies, which also showed a reduction in blood pressure in individuals on a vegetarian diet compared to those following an omnivorous diet. Previous analyses indicate that a plant-based diet can reduce systolic blood pressure by 4.8 mmHg in controlled studies and 6.9 mmHg in observational studies, as well as by 2.2 mmHg and 4.7 mmHg, respectively, for diastolic blood pressure. The reduction in blood pressure resulting from a vegetarian diet is particularly significant for individuals with comorbid conditions, as a decrease in systolic blood pressure by 1-2 mmHg can substantially reduce the risk of cardiovascular diseases, including coronary artery disease, stroke, and heart failure. The mechanisms responsible for these benefits include lowering cholesterol levels, which supports blood pressure control, as well as the high content of fiber, polyunsaturated fatty acids, antioxidants, and phytochemicals in the vegetarian diet. Comparisons between different types of vegetarian diets suggest that a vegan diet may lower blood pressure more than a lacto-ovo-vegetarian diet, which may be related to the absence of animal products that may contain saturated fatty acids, negatively affecting lipid profiles and increasing the risk of atherosclerosis. Research findings also indicate that a vegetarian diet is more effective in lowering systolic blood pressure in individuals without diabetes, while those with diabetes show a greater reduction in diastolic blood pressure. In conclusion, a plant-based diet is a promising, non-pharmacological method for controlling hypertension, which may contribute to a reduction in the incidence of cardiovascular diseases and improve the health of the population [14].

## **Vegetarian diet and its impact on ischemic heart disease**

Cardiovascular diseases are the leading cause of death worldwide, accounting for 46% of deaths from non-communicable diseases. Adopting healthy lifestyle habits, particularly a proper diet, can reduce the risk of heart attack by more than 80% [15]. Ischemic heart disease is the result of the progressive atherosclerotic process in the coronary arteries or disturbances in coronary circulation. It can be managed through lifestyle changes, pharmacological treatment, and revascularization procedures. These methods can help slow the progression of the disease or even reverse it [16]. It is often associated with the presence of an atherosclerotic plaque, which causes narrowing of blood flow in the large and medium coronary arteries. However, clinical, angiographic, and autopsy studies indicate that its pathophysiology is more complex, and only a portion of cases result from the presence of advanced or complicated atherosclerotic plaques. Despite advancements in prevention and treatment strategies for this condition in recent years, ischemic heart disease still represents a major health challenge, significantly affecting mortality and morbidity rates [17].

Jarbi A et al., in their meta-analysis, indicate a 30% relative reduction in the risk of mortality from ischemic heart disease among vegetarians. The key factor behind this phenomenon is the reduction of risks associated with heart disease, which may stem from the beneficial effects of a vegetarian diet on body weight, lipid profile, blood pressure, diabetes, and other chronic diseases. From a metabolomic perspective, its benefits arise from the abundance of health-promoting compounds in plants and the reduction of harmful substances present in meat, such as heme iron, saturated fats, and Neu5Gc. Furthermore, a plant-based diet influences metabolic pathways, including the growth hormone axis, IGF-1, sirtuins, AMPK, and mTOR, which may support heart health and reduce mortality. It has also been observed that vegetarianism is often associated with a healthy lifestyle, including the avoidance of substances such as alcohol and tobacco, which further enhances its health-promoting effects [18].

Studies from 2022 showed a 21% lower relative risk of ischemic heart disease (IHD) in vegetarians and 18% in vegans compared to individuals consuming meat. These results are consistent with earlier studies, which indicated that individuals following plant-based diets have a lower body mass index (BMI), slower weight gain, lower total cholesterol and LDL levels, reduced blood pressure, and a lower risk of type 2 diabetes - key risk factors for cardiovascular diseases. Randomized studies suggest that a vegetarian diet lowers LDL levels by 12.2 mg/dl and systolic blood pressure by 4.8 mmHg. These changes could reduce the risk of mortality from IHD by 10% and 11%, respectively. The combined effects of these factors likely explain the observed 21% reduction in risk among vegetarians [19].

Studies have shown that the endothelium, which lines blood vessels, is responsible for regulating vascular tone, angiogenesis, and preventing leukocyte adhesion. Its proper function can be disrupted by factors such as an improper diet, lack of exercise, hypertension, and chronic inflammation. A high intake of meat is associated with impaired endothelial function, while a diet rich in fruits and vegetables promotes its improvement by lowering levels of inflammatory biomarkers such as CRP, interleukin-6, and soluble intercellular adhesion molecule, all of which are linked to cardiovascular diseases.

Additionally, a plant-based diet reduces the production of trimethylamine N-oxide (TMAO), a substance formed from phosphatidylcholine and carnitine found in foods like meat, dairy, and eggs. TMAO, produced by gut bacteria, promotes atherosclerosis, increasing the risk of heart attacks and strokes. In vegetarians, the production of this compound is lower, which translates into a reduced risk of cardiovascular diseases [20].

### **Vegetarian diet and its impact on metabolic syndrome**

Metabolic syndrome is characterized by a set of reversible risk factors that increase the likelihood of developing type 2 diabetes and cardiovascular diseases. The diagnosis includes elements such as elevated triglyceride levels, high blood pressure, low HDL cholesterol levels, and elevated blood glucose levels. These factors are often associated with excessive weight gain, particularly around the abdomen, leading to an increased waist circumference. Currently, this issue affects 30–40% of individuals over the age of 65 and is continuously worsening, mainly due to increasing body weight in adulthood and genetic predispositions. The primary element of treatment for metabolic syndrome is lifestyle modification, aimed at reducing body weight. This requires implementing a healthier diet and increasing physical activity [21,22].

Plant-based diets have a beneficial impact on cardiometabolic health, reducing the risk of metabolic syndrome and its individual components. They are also associated with a decreased risk of obesity, type 2 diabetes, cardiovascular diseases, and a reduction in overall mortality. As previously demonstrated in this paper, a vegetarian diet contributes to the reduction of lipid levels and blood pressure, which are key components of metabolic syndrome. Moreover, numerous studies confirm that individuals following plant-based diets often experience significant weight loss. Key characteristics of these diets include high fiber content, low energy density, and a favorable fat profile, rich in unsaturated fatty acids. These factors promote improved insulin sensitivity and exhibit anti-inflammatory effects. Additionally, plant-based foods are a source of numerous antioxidants, such as vitamins C and E and polyphenols, which support metabolic health and cardiovascular health. Therefore, implementing a vegetarian diet in individuals with metabolic syndrome can bring significant health benefits, making it a valuable component of the treatment strategy for this condition [23].

### **Risks associated with following a vegetarian diet**

Despite the numerous benefits of following a vegetarian diet, it is also important to consider potential health risks. The most common issues include deficiencies in vitamins, particularly vitamin B12, as well as minerals such as iron, zinc, calcium, and protein. A lack of adequate amounts of these nutrients in the diet can lead to serious health consequences, including general weakness, anemia, or an increased risk of bone fractures [24].

Vitamin B12 deficiency in individuals following a plant-based diet primarily results from the fact that plants do not synthesize this compound. As a result, there is a significant difference in B12 intake between meat-eaters, who consume an average of 7.2 µg daily, and vegans, whose intake is only 0.4 µg. Vitamin B12 plays a crucial role in essential metabolic reactions within the body and is necessary for the production of blood cells and the proper functioning of the nervous system. Its deficiency can lead to anemia and pregnancy complications, such as developmental defects, miscarriages, low birth weight, and preeclampsia.

Adequate levels of vitamin B12 during pregnancy and the perinatal period are essential for brain development, cognitive function, nerve myelination, and infant growth. Studies suggest that a healthy individual should consume about 6 µg of this vitamin daily, while older adults and individuals with comorbidities may need as much as 20 µg. For this reason, vitamin B12 supplementation is recommended for those following plant-based diets [25].

Based on the article by Pawlak R et al., it was found that vegetarians have lower ferritin levels, indicating reduced iron stores in the body. Lower ferritin levels were primarily observed in women who are actively menstruating. Prolonged low iron levels may lead to microcytic anemia, which was more frequently diagnosed in individuals following a plant-based diet compared to non-vegetarians. The lower iron stores in vegetarians can be explained by its limited bioavailability in plant-based foods, due to the presence of absorption inhibitors such as oxalates and phytates [26].

Eric Slywitch and colleagues obtained similar results in their study, confirming lower ferritin levels in vegetarians. However, they pointed out that ferritin, being an acute-phase protein, is elevated in individuals with higher levels of inflammation, which tends to be lower in vegetarians compared to omnivores. Therefore, the authors emphasize the need for further research on the iron content in the body, taking into account the levels of C-reactive protein (CRP) [27].

## **Conclusion**

As presented in our review, a vegetarian diet has a range of beneficial effects on the cardiovascular system. Studies consistently show that this diet effectively lowers blood pressure, making it a valuable tool both in prevention and as an adjunct to the treatment of hypertension. Additionally, the vegetarian diet has a positive impact on coronary artery disease, significantly reducing the risk of mortality from this cause. However, despite its numerous positive effects, potential risks associated with its implementation should not be overlooked. Particular attention should be paid to the risk of vitamin B12 and iron deficiencies, which can lead to anemia. Therefore, proper supplementation of these nutrients is essential when following a vegetarian diet. In conclusion, a vegetarian diet has a positive impact on cardiovascular health, but further research is still needed to fully assess its safety and long-term effectiveness.

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