The Impacts and Applications of Micronutrients for Cardiovascular Diseases

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Abstract. Cardiovascular diseases (CVDs), such as stroke, coronary heart disease (CHD), heart failure (HF), and hypertension, remain the primary cause of death globally. Growing evidence suggests that daily intake of micronutrients, including minerals, vitamins, and polyunsaturated fatty acids (PUFAs), plays a critical role in reducing the risk of CVDs. This article provides a comprehensive analysis of current research, highlighting how these micronutrients mitigate CVD risk by reducing inflammation, enhancing lipid metabolism, regulating blood pressure, and lowering the incidence of disease in at-risk populations. Regular consumption of appropriate levels of micronutrients can not only prevent the onset of CVDs but also improve health outcomes in patients already suffering from these conditions. Additionally, this paper underscores the importance of dietary habits in CVD prevention across various age groups. Despite the promising role of micronutrients, further research is required to establish their efficacy in treating existing cardiovascular conditions, presenting opportunities for future clinical studies.

Keywords: Cardiovascular diseases, minerals, vitamins, and polyunsaturated fatty acids (PUFAs).

1. Introduction

Cardiovascular diseases (CVDs) include various conditions that impact the heart and blood vessels, such as stroke, coronary artery disease (CAD), heart failure (HF), and high blood pressure. These conditions are leading cause of death globally, accounting for about 17.9 million deaths annually, and over 20 million deaths in 2021, which is approximately 32% of all global deaths [1,2]. The burden of CVDs has increased significantly over the past century, largely due to lifestyle changes and the prevalence of risk factors such as smoking, unhealthy diets, obesity and physical inactivity. Some research has indicated that micronutrients play a essential role in the prevention of CVDs. Micronutrients are essential nutrients required by the body in small amounts to perform a wide range of physiological functions. Unlike macronutrients (such as carbohydrates, proteins, and fats), which are needed in larger quantities, micronutrients are vital for proper growth, development, and maintenance of bodily functions, even though they are required in minute quantities [3].

Deficiencies or imbalances in certain micronutrients can contribute to the development of CVDs. For example, low levels of potassium, magnesium, and calcium have been linked to hypertension, a major risk factor for CVDs. Similarly, deficiencies in antioxidants like vitamins C and E can lead to oxidative stress, which is associated with the progression of atherosclerosis. Research on micronutrients is highly significant for the prevention of CVDs through decreasing the reflection of inflammation, improving lipid metabolism pathways, adjusting blood pressure and helping to reduce the incidence of disease in patients to reduce mortality among patients with these conditions. On the other hand, adequate intake of these micronutrients can help prevent CVDs. For instance, omega-3 fatty acids, found in fish oil, have been shown to reduce inflammation and lower the risk of heart disease. Additionally, dietary sources of fiber and plant-based foods, rich in micronutrients, are associated with lower cholesterol levels and reduced CVD risk. Although many articles have studied the relationship between micronutrients and CVDs, there are many aspects to continue discussing. Therefore, the current review will continue to explore the effects of micronutrients and further discuss the mechanisms by which micronutrients reduce the risk of CVDs. Some applications in the prevention of CVDs will be discussed as well. Methods that micronutrients reduce the risk of CVDs, and the consequences of their deficiency will be discussed by comparing two different diets:

recommended dietary allowance and normal serum concentration dietary. The mechanism of five key micronutrients (iron, selenium, zinc, copper and coenzyme Q10) and they how to impact on HF will be discussed by analysing mitochondrial dysfunction.

2. Role of Different Nutrients in CVDs

2.1. Biological Role of Minerals in the Cardiovascular System

Minerals are essential micronutrients in the biological system in particular in cardiovascular system. Calcium is a pivotal mineral in heart health. Mature men and women should consume 1,200–1,500 milligrams of calcium daily. It is often insufficient to meet the recommended calcium intake through food alone, so many people supplement with calcium tablets in their daily lives [4]. According to some observational and clinical trials, the concentration of extracellular calcium can influence myocardium contraction through impacting the membrane potentials of all excitable tissues in the heart and nervous system [5]. This means that calcium can regulate blood vessels and the body's systems to some extent. Therefore, calcium can decrease the risk of CVDs through adjusting blood pressure, decreased the fat content in the blood and effectively improve blood sugar levels. In a meta-analysis, it was reported that daily calcium intake of less than or greater than 800 milligrams is associated with an increased risk of cardiovascular mortality [6]. Calcium is crucial not only for the ability of muscle to contract but also for generating and regulating Cardiac rhythm and metabolic processes. The impact of calcium on various heart conditions, including arrhythmia, HF, and ischemic heart disease, warrants discussion. A meta-analysis indicates that consuming 700–1000 mg of calcium per day through diet or supplementing with 1000 mg/day significantly raises the risk of cardiovascular and ischemic heart disease. Additionally, later meta-analyses have found that using calcium alone as a treatment for CAD is linked to an increased risk of myocardial infarction (MI) [4].

Therefore, if the deficiencies in the intake of calcium in daily life, the risk of CADs and MI will be increased. Zinc has many functions, among which its role as an antioxidant is one of the most important. It inhibits the production and reactive behavior of free radicals which lead to a series of diseases and destroy cells [4]. Zinc is involved in nucleic acid metabolism and protein biosynthesis, ensuring normal cell processes such as growth, division and function. Zinc deficiency is linked to the development of CVDs, particularly atherosclerosis. The impaired function of superoxide dismutase leads to oxidative stress, which increases the breakdown of nitric oxide (NO), a powerful vasodilator that can influence arterial pressure [4]. Additionally, heightened oxidative stress can contribute to atherosclerosis [4]. A study about mic showed that insufficient consumption of Zn resulted in higher concentrations of lipoproteins, increased remodeling of vascular smooth muscle, heightened inflammation, and the formation of atherosclerotic plaques. Zinc supports the proper function of superoxide dismutase and helps regulate NO production [4].

2.2. The Role of Vitamins in Heart Health

α-tocopherol (vitamin E) can not only inhibit the function of protein kinase C but also lower the risk of cardiovascular disease (CVD) by decreasing blood cholesterol and triglyceride levels, which are significant risk factors for CVD [3]. Some people found that there are some associations between the ingestion of Vitamin K (VK) and the risk of death from HF. When people get the recommended intake amount of VK, the risk of death from HF will be decreased. Based on the findings of a scientific study not currently accessible, when women take vitamin E continuously for more than two years, their risk of cardiovascular disease is lower compared to those who do not exceed two years of vitamin E use [3]. In intervention studies, some researchers have found that taking VE alone can effectively alleviate myocardial infarction. If the lack of vitamin B12 and B9 in the body, it will lead to an increase in total homocysteine (tHcy) in the blood, which is associated with the progression of CVD [3]. The supplementation of folic acid and vitamin B12 are important because they decrease blood homocysteine levels which increase the risk of stroke. A healthy vascular endothelium is essential to prevent cardiovascular complications like ischemic stroke, but elevated homocysteine levels can lead

to endothelial dysfunction through various pathways. These include increased oxidative stress, reduced NO availability, heightened endothelial inflammation with the activation of vascular adhesion molecules and recruitment of leukocytes, all of which contribute to platelet activation and thrombosis. These effects of endothelial dysfunction worsen every stage of ischemic stroke, from the initial development of atherosclerosis to the formation of thrombosis. It has been proved B12 and folic acid that have some impacts on decreasing the risk of CVDs in some clinical studies.

2.3. Polyunsaturated Fatty Acids (PUFAs) Play an Essential Role in Preventing CVDs

PUFAs have an important effect on physiological processes which preventing and treat CVDs [5]. As shown in Figure 1, PUFAs regulate blood flow and inflammation in the blood vessel walls., offering anti-inflammatory and atheroprotective benefits that help prevent CVDs [6]. In long-term studies, individuals at high risk for coronary artery disease who consumed fish-derived n-3 PUFAs showed a reduction in mortality, while other trials involving n-3 PUFA supplementation, such as the Indian Experiment of Infarct Survival and the Gruppo Italiano trial, demonstrated lower cardiac events and a decrease in sudden cardiac death, though the latter did not find a reduction in nonfatal myocardial infarction [5]. Epidemiologic studies have demonstrated a link between high seafood consumption, rich in n-3 PUFAs, and low cardiovascular morbidity [7]. In Japan, atherosclerotic indicators like aortic pulse wave velocity and carotid artery intima-media thickness are lower in fishing villages compared to farming villages for both men and women. The Japan Public Health Center-based study found that higher fish intake significantly reduces the risk of CHD, particularly nonfatal heart incidents, among middle aged and elderly people. In the Netherlands, people who eat at least 29 grams of fish daily have a 55% lower risk of cardiovascular disease compared to those who do not consume fish. This indicates that fish consumption plays an important role in preventing cardiovascular disease. Middle-aged and elderly individuals can increase their fish intake as part of their regular diet. A meta-analysis revealed that increased n-3 PUFA intake from fish or fish oil supplements, reduces all-cause mortality, cardiac death, and incidence of sudden fatalities [7]. Another meta-analysis also found that the more n-3 PUFA consumed, the lower the risk of CVDs. Therefore n-3 PUFAs may aid in the prevention of CVD through multiple mechanisms, such as serving as an anti-atherogenic agent, lowering serum triglycerides, slightly reducing blood pressure, enhancing endothelial function, diminishing inflammatory responses, inhibiting platelet aggregation and thrombosis, and decreasing the occurrence of arrhythmias [5].

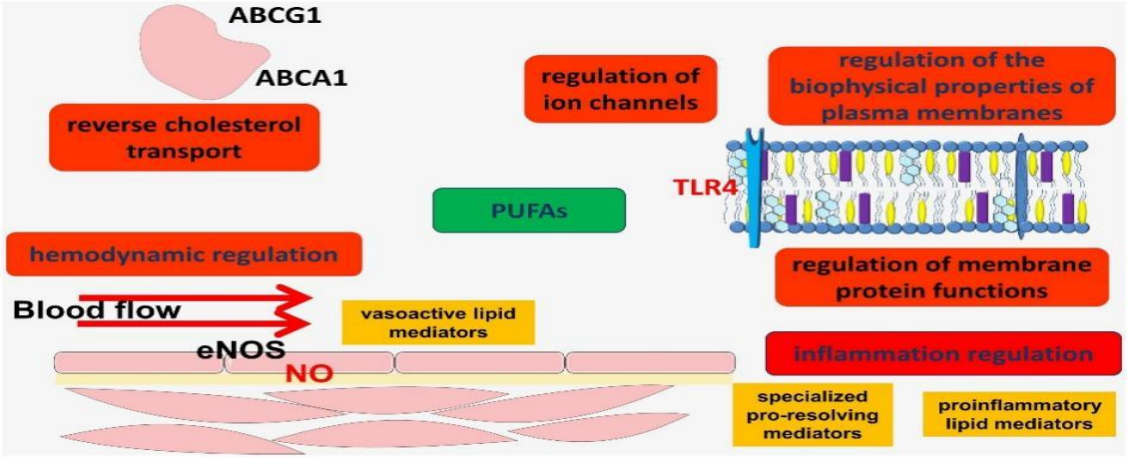

Fig. 1 The role of PUFAs in the regulation of CVDs [6].

2.4. Application in Prevention

A healthy diet can play a crucial role in preventing CVDs. By including a variety of nutrient-dense foods such as fruits, vegetables, whole grains, lean proteins, and healthy fats, while limiting the intake of processed foods, sugars, and unhealthy fats, individuals can significantly reduce their risk of developing CVDs. A balanced diet helps in maintaining healthy blood pressure, cholesterol levels,

and body weight, all of which are key factors in preventing heart-related conditions. Regular consumption of heart-healthy nutrients like omega-3 fatty acids, fiber, and minerals further supports cardiovascular health by reducing inflammation, improving lipid profiles, and enhancing overall vascular function. The application of micronutrients in preventing CVDs involves ensuring adequate intake of essential vitamins, minerals and PUFAs that support heart health. According to the 2017 AHA/ACC Hypertension Guidelines, lifestyle changes and nonpharmacologic measures are crucial for preventing and lowering systolic blood pressure (SBP) in individuals at risk for or diagnosed with high blood pressure [8]. A low-sodium diet can effectively reduce CVDs and lower blood pressure. In studies on the DASH diet, it was concluded that limiting sodium intake can decrease systolic blood pressure [8]. In addition, studies have shown that potassium-rich fruits and vegetables can lower blood pressure. This can be incorporated into daily diets and recommended for CVDs patients [8]. Therefore, it can prevent the risk of CVDs through changing and adjusting the daily dietary pattern.

3. Conclusion

In conclusion, minerals, vitamins and PUFAs have an effect on adjusting the mechanisms of CVDs and decreasing the risk of CVDs through above studies indicating, so micronutrients play an essential role in preventing CVDs. Based on the analysis of the above investigations, if we consistently consume an appropriate number of micronutrients over the long term, it can effectively prevent CVDs. Additionally, regular intake of micronutrients can improve the condition of CVD patients. Therefore, people can prevent CVDs by supplementing with vitamins, minerals and PUFAs in their daily routine. The main contribution of this article is to analyze the effect of micronutrients on preventing CVDs and how vitamins, minerals and PUFAs play an important role in stroke, CHDs, HF and hypertension respectively. It is beneficial for people of different age groups to prevent CVDs by supplementing with micronutrients, and they can reduce the risk of developing CVDs by improving their daily dietary habits. Current research still lacks sufficient evidence on whether micronutrients can aid in the treatment of CVDs. Future studies could focus on this area and provide a variety of methods to explore this potential.

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