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Moderate Coffee Consumption and Cardiovascular Health: Literature Review of Benefits, Risks and Individual Variations

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Abstract

The study aims to evaluate the relationship between coffee consumption and cardiovascular risk by using literature review approach. The findings reveal that moderate coffee consumption has been associated with various cardiovascular benefits, including reduced mortality and improved metabolic health, particularly among individuals with healthy lifestyles and without pre-existing conditions such as hypertension or metabolic syn-drome. Bioactive compounds in coffee, including caffeine, phenolic acids, and antioxidants, contribute to these benefits by reducing inflammation, enhancing vascular function, and improving insulin sensitivity. However, excessive coffee consumption can have adverse cardiovascular effects, such as elevated blood pressure and increased risk of arrhythmias, especially in individuals with hypertension or genetic predispositions to caffeine sensitivity. Genetic factors, such as variations in the CYP1A2 gene affecting caffeine metabolism, further modulate individual responses to coffee. This highlights the need for personalized recommendations that consider genetics, health status, and consumption patterns to optimize coffee's cardiovascular benefits. Additionally, understanding the timing of coffee intake in relation to individual metabolic rhythms may further enhance its health-promoting potential.

Keywords

Coffee, Cardiovascular Health, Caffeine, Inflammation, Metabolic Health

1. Introduction

The relationship between coffee consumption and cardiovascular health has become an increasingly intriguing topic of research in recent years. Coffee, as a complex beverage, contains various bioactive compounds such as caffeine, polyphenols, and antioxidants, which have the potential to exert both positive and negative effects on health (Qi et al., 2024; Wen et al., 2024). Recent studies have explored the impact of coffee on various cardiovascular conditions, including heart failure, stroke, and hypertension. On one hand, coffee consumption is often associated with cardiovascular benefits, such as improved endothelial function, reduced inflammation, and enhanced glucose metabolism. Some studies suggest that moderate coffee consumption may lower the risk of coronary heart disease and stroke. These protective effects are likely attributed to the antioxidant and polyphenol content in coffee, which can combat oxidative stress and improve vascular health.

Excessive coffee consumption, particularly among individuals sensitive to caffeine, may cause temporary increases in blood pressure, palpitations, and overstimulation of the central nervous system (Farber et al., 2024). This raise concerns that high coffee intake could increase the risk of hypertension or arrhythmias in certain groups. This literature review aims to synthesize findings from various recent studies evaluating the relationship between coffee consumption and cardiovascular risk. The review seeks to provide a more comprehensive understanding of the benefits and risks of coffee consumption and offer insights for better decision-making regarding coffee intake to support cardiovascular health (Bhandari et al., 2024). By analyzing factors such as consumption dosage, coffee type, and individual variability, this review is expected to make a significant contribution to the scientific literature on cardiovascular health (Ungvari & Kunutsor, 2024).

Several studies emphasize the potential cardioprotective effects of moderate coffee consumption, typically defined as 1-5 cups per day. These protective effects are largely attributed to the bioactive compounds in coffee, such as polyphenols, antioxidants, and caffeine, which have been shown to reduce oxidative stress and inflammation. These mechanisms help mitigate metabolic risk factors, including insulin resistance and hypertension, both of which are closely linked to cardiovascular diseases (Setia Santoso et al., 2024; Karagöz et al., 2024). A significant body of evidence supports the hypothesis that moderate coffee consumption does not pose long-term cardiovascular risks. Mendelian randomization analyses, which utilize genetic variants as proxies for specific exposures to reduce confounding factors, have consistently shown no significant association between coffee consumption and increased cardiovascular risk. On the contrary, such analyses, along with observational studies, suggest that coffee consumption may lower the risk of developing certain conditions, including heart failure.

Further, emerging research highlights the role of coffee in reducing the likelihood of transitioning from single cardiometabolic conditions, such as type 2 diabetes or coronary heart disease, to a state of multimorbidity. This finding is particularly significant in understanding how coffee can contribute to long-term cardiometabolic health. A study by Sun et al. (2024) and Chen et al. (2024) demonstrated that individuals who consumed coffee regularly had a lower risk of progression to multimorbid conditions, underscoring coffee's potential role in mitigating the broader burden of chronic diseases. These findings collectively suggest that moderate coffee consumption, when incorporated into a balanced lifestyle, may play a supportive role in cardiovascular and metabolic health. However, individual variability in response to coffee, including genetic predispositions to caffeine sensitivity and underlying health conditions, must be considered when considering its broader health implications (Quarti-Trevano et al., 2024).

However, excessive coffee consumption (more than 6 cups per day) has been associated with increased cardiovascular risk, particularly in individuals with pre-existing health conditions such as hypertension or arrhythmias (Setia Santoso et al., 2024; Han et al., 2024). The timing of coffee consumption also plays a crucial role in its cardiovascular effects, especially in people with diabetes. Studies have shown that consuming coffee early in the morning may increase the risk of all-cause mortality, cardiovascular disease (CVD), and diabetes-related mortality, while consuming it later in the day can reduce these risks (Yang et al., 2024). Furthermore, genetic factors, such as the LPL gene variant, may influence how individuals respond to coffee, highlighting the need for personalized recommendations (Hsieh et al., 2024). This review synthesizes these findings, emphasizing that moderate coffee consumption, combined with a healthy lifestyle, may offer cardiovascular benefits, but its consumption should be carefully tailored to individual health profiles.

2. Methods

This literature review aims to evaluate the relationship between coffee consumption and cardiovascular risk by analyzing studies published in reputable peer-reviewed journals. All studies included in the review were sourced from the Scopus database, focusing on current publications up until 2024. To identify relevant studies, a comprehensive search strategy was employed, using key terms such as "coffee consumption," "cardiovascular health," "heart disease," "hypertension," and "diabetes" to ensure a broad yet targeted selection of articles. These terms were used in various combinations to capture studies exploring both the positive and negative effects of coffee on cardiovascular health and related outcomes.

Studies were included if they met the following criteria: (1) they were published in the last five years (2020–2024), (2) they focused on adult populations, (3) they examined the effects of coffee consumption on cardiovascular outcomes such as mortality, heart disease, stroke, hypertension, or other relevant cardiovascular conditions, and (4) they employed quantitative or qualitative research methods. A total of 16 studies met these criteria, providing a diverse range of data on the effects of coffee consumption. The analysis performed was descriptive in nature, summarizing the findings across studies without applying statistical models. This approach allowed for an understanding of the varying impacts of coffee on cardiovascular health, including beneficial and harmful effects, as well as the influence of moderating factors such as genetics, timing of consumption, and lifestyle factors. Data was extracted and categorized based on the types of outcomes reported, such as mortality, cardiovascular diseases, and related risk factors like hypertension and diabetes.

3. Results

The relationship between coffee consumption and cardiovascular health has been a topic of extensive research, with evidence suggesting both potential benefits and risks depending on various factors such as the amount consumed, timing, and individual characteristics. This discussion aims to extract, categorize, and explore recent findings on coffee's impact on cardiovascular health, focusing on several key aspects. First, we examine the general relationship between coffee consumption and cardiovascular risk, highlighting both the protective and harmful effects identified in the literature. We then explore the timing of coffee consumption, particularly how consuming coffee at different times of day can influence cardiovascular outcomes, especially in individuals with diabetes. Further, we discuss coffee's role in reducing the risk of cardiometabolic multimorbidity, where coffee may help lower the likelihood of progressing from single diseases to multiple chronic conditions. The interaction between sedentary behavior and coffee consumption is another important

aspect, with studies suggesting coffee may mitigate some risks associated with a sedentary lifestyle. Additionally, we consider genetic factors and their potential influence on how individuals respond to coffee. Finally, we review the effects of coffee on hypertension, and the underlying mechanisms that explain coffee's cardiovascular impact. Each of these sections will provide insights into the complex interplay between coffee and heart health.

3.1. Coffee Consumption and Cardiovascular Risk, Timing of Coffee Consumption, and Coffee and Multimorbidity

Several studies have examined the relationship between coffee consumption and cardiovascular risk, revealing both potential benefits and harms depending on the quantity and timing of consumption. Moderate coffee consumption, generally defined as 1-5 cups per day, has been associated with reduced risks of heart failure and cardiovascular events in numerous studies. For instance, the 4C Study indicated that moderate coffee consumption may slightly increase the risk of developing type 2 diabetes, but does not significantly contribute to cardiovascular mortality. Conversely, Mendelian randomization analyses have demonstrated that moderate coffee intake (1-5 cups per day) is not associated with significant long-term cardiovascular risks, suggesting a neutral or potentially beneficial effect on heart health. The bioactive compounds found in coffee, such as antioxidants, polyphenols, and caffeine, have been identified as contributing factors to these protective effects by reducing oxidative stress, inflammation, and improving endothelial function (Setia Santoso et al., 2024). However, excessive coffee consumption—particularly more than 6 cups per day—has been linked to increased risks of cardiovascular diseases and mortality, primarily due to the high caffeine and diterpene content, which may exacerbate conditions such as hypertension and arrhythmias (Han et al., 2024).

The timing of coffee consumption also plays a significant role in its cardiovascular impact, particularly among individuals with diabetes. Yang et al. (2024) found that drinking coffee early in the morning (from dawn to forenoon) was associated with an increased risk of all-cause mortality, cardiovascular disease (CVD), and diabetes-related mortality. In contrast, consuming coffee later in the day (from forenoon to noon) was linked to reduced risks of overall mortality and cardiovascular events. This suggests that the timing of coffee consumption could influence its cardiovascular effects, particularly for individuals with diabetes. These findings highlight the importance of considering not only the quantity of coffee consumed but also the time of day at which it is consumed to optimize health outcomes.

Coffee consumption has also been associated with a reduced risk of cardiometabolic multimorbidity (CMM), a condition where individuals suffer from multiple interconnected diseases like type 2 diabetes, coronary heart disease, and stroke. A study using data from the UK Biobank showed that individuals who regularly drank coffee had a lower risk of transitioning from a single cardiometabolic disease to multimorbidity (Sun et al., 2024). Specifically, moderate coffee intake was linked to lower transition risks from heart disease and stroke to multimorbidity, suggesting that coffee may offer protective benefits for individuals with existing cardiometabolic conditions. Additionally, the study indicated that unsweetened coffee provided the most consistent benefits, as opposed to sweetened versions, which may negate some of the health benefits due to the added sugar.

3.2. Sedentary Lifestyle and Coffee Consumption, Genetic Interaction with Coffee, and Coffee and Hypertension

The relationship between sedentary behavior and coffee consumption was explored by Zhou et al. (2024), who found that long periods of sedentary behavior (sitting for more than 8 hours per day) were associated with increased risks of all-

cause mortality and cardiovascular disease (CVD). However, coffee drinkers exhibited lower mortality rates, especially when combined with less sedentary behavior. This suggests that coffee may help mitigate some of the harmful effects of a sedentary lifestyle, particularly in relation to cardiovascular health. The positive effects of coffee may stem from its ability to improve metabolic function and reduce inflammation, both of which are key contributors to cardiovascular diseases. Thus, while physical activity remains crucial for heart health, moderate coffee consumption could be an additional factor in reducing cardiovascular risk, particularly for those who have sedentary lifestyles.

Genetics plays a significant role in determining how individuals respond to coffee, particularly concerning metabolic syndrome (MetS). Hsieh et al. (2024) investigated the interaction between the LPL gene variant (rs301) and coffee consumption in individuals with MetS. The study found that coffee drinkers with the 'TC' and 'CC' genotypes of the LPL gene had a lower risk of developing MetS compared to non-drinkers. This suggests that genetic factors may influence how coffee consumption affects metabolic health, particularly in those at higher genetic risk for metabolic disorders. This finding underscores the importance of considering genetic predispositions when assessing the health effects of coffee, as certain individuals may benefit more from coffee consumption than others.

The effects of coffee on individuals with hypertension have been a subject of considerable interest. Moderate coffee intake (1-2 cups per day) is generally considered safe for individuals with hypertension and may even be associated with a reduced risk of cardiovascular mortality. A study by Zhang et al. (2024) found that hypertensive individuals who consumed moderate amounts of coffee had a lower risk of all-cause mortality compared to non-coffee drinkers. However, excessive coffee consumption (greater than 6 cups per day) can exacerbate hypertension-related complications, leading to an increased risk of cardiovascular mortality and stroke. Studies have indicated that the high caffeine content in coffee may raise blood pressure, particularly in sensitive individuals or those with pre-existing hypertension. Therefore, it is crucial for hypertensive individuals to limit their coffee intake to moderate levels to avoid potential negative effects on cardiovascular health.

3.3. Mechanisms of Action

Coffee exerts its cardiovascular effects through its rich and complex chemical composition, which includes bioactive compounds such as caffeine, melanoidins, and phenolic acids. These components collectively contribute to coffee's potential cardioprotective properties. Caffeine, the most prominent compound, has been shown to improve endothelial function and induce mild vasodilation, which can aid in lowering blood pressure in certain individuals. It also stimulates the release of nitric oxide, a critical molecule that supports vascular health and prevents the formation of atherosclerotic plaques. Meanwhile, phenolic acids, particularly chlorogenic acid, serve as powerful antioxidants that neutralize free radicals and mitigate oxidative stress, a major contributor to cardiovascular diseases like coronary artery disease and hypertension. Melanoidins, formed during the roasting process, further enhance coffee's cardiovascular benefits by reducing inflammation and improving lipid metabolism. These compounds are associated with lowered levels of oxidized LDL cholesterol and improved HDL cholesterol, contributing to a reduced risk of atherosclerosis and other lipid-related conditions. Additionally, coffee has been linked to better glucose metabolism and enhanced insulin sensitivity, which are essential for preventing metabolic disorders that often lead to cardiovascular complications.

Despite these benefits, the effects of coffee are highly dose-dependent and can vary based on individual biological factors, including genetic predispositions. Excessive caffeine intake can overstimulate the central nervous system, potentially causing adverse outcomes such as arrhythmias, elevated blood pressure, and

increased heart rate, especially in individuals sensitive to caffeine or those with a predisposition to hypertension. The relationship between coffee and cardiovascular health is further complicated by genetic factors. Variations in the CYP1A2 gene, which governs caffeine metabolism, influence how quickly caffeine is processed in the body. Slow metabolizers of caffeine may experience prolonged exposure to its stimulatory effects, increasing their susceptibility to adverse cardiovascular outcomes. Similarly, genetic variations in the LPL (lipoprotein lipase) gene affect lipid metabolism, altering the degree to which coffee influences lipid profiles. These individual differences underscore the importance of moderation and personalization in coffee consumption. While moderate intake—typically 1-5 cups per day—has been associated with significant cardiovascular benefits, overconsumption can negate these effects and increase health risks. As research advances, personalized dietary guidelines that consider genetic and metabolic variability may provide more precise recommendations for optimizing coffee's role in supporting cardiovascular health.

4. Conclusion

A literature review highlights that moderate coffee consumption, typically 1-5 cups per day, is associated with significant cardiovascular benefits, including reduced mortality and improved metabolic health. These benefits are particularly evident among individuals with healthy lifestyles who are free from pre-existing conditions such as hypertension or metabolic syndrome. Coffee's bioactive compounds, such as caffeine and antioxidants, contribute to these protective effects by reducing inflammation, enhancing vascular function, and improving insulin sensitivity. However, excessive coffee consumption can lead to adverse cardiovascular outcomes, especially in individuals with hypertension or a genetic predisposition to caffeine sensitivity. High caffeine intake may elevate blood pressure, increase heart rate, and exacerbate the risk of arrhythmias. Variations in genes such as CYP1A2, which affects caffeine metabolism, further influence how individuals respond to coffee, emphasizing the importance of personalized consumption guidelines. To optimize the health benefits of coffee, recommendations should consider factors such as genetic predispositions, overall health status, and the timing of consumption. More research is needed to understand the long-term effects of coffee on cardiovascular health across diverse populations, accounting for differences in genetics, dietary patterns, and lifestyle factors. This knowledge will help create tailored approaches to maximize coffee's cardioprotective potential.

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