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Review Article

Coffee and Blood Pressure: Enemy or Friend?

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ABSTRACT

Coffee is one of the most consumed drink, with around 2.3 billion cups being consumed every day across the world. It is the most popular drink after water. Many studies have revealed that drinking coffee regularly and within limit, can have positive effects on the nervous system, digestive system, and cardiovascular systems, as well as on the renal system. However, there is a lot of debate about how coffee affects blood pressure and the risk of high blood pressure, which is a common, condition affecting 31.1% of adults worldwide. There are also many discussions about whether coffee is safe for people with high blood pressure. Recent studies have identified many chemical compounds in coffee, including caffeine,trigonelline, kahweol, chlorogenic acidand others. These compounds can have different impacts on blood pressure.

Keywords: Coffee, Blood Pressure, Caffeine, Cardiovascular,Chlorogenic acid, Trigonelline.

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INTRODUCTION

Coffee is one of the most consumed drinks, with around 2.3 billion cups being consumed every day across the world. It is the most popular drink after water. Many studies have revealed that drinking coffee regularly and within limit, can have positive effects on the nervous system, digestive system, and cardiovascular systems, as well as on the renal system. However, there is a lot of debate about how coffee affects blood pressure and the risk of high blood pressure, which is a common, condition affecting 31.1% of adults worldwide. There are also many discussions about whether coffee is safe for people with high blood pressure. Recent studies have identified many chemical compounds in coffee, including caffeine, trigonelline, kahweol, chlorogenic acid and others. These compounds can have different impacts on blood pressure.[9]

Hypertension is a widespread and serious health issue in today's world. It affects more thanone billion adults'word wide, and is expected to rise by coming years. Hypertension raises the risk of several cardiovascular pathology (myocardial infarction, pump failure leading to death, stroke and peripheral artery disease) and advance stage ofrenal diseases. However, hypertension can potentially be prevented or reducing further mortality risk by changing factors like lifestyle and dietary.[1] One of the dietary habits that have been considered harmful is coffee consumption, as some studies have linked it with risk of increase blood pressure. However, more recent study showed that some variables that were overlooked, such as concurrent smoking habits and socioeconomic status have influenced the results of many studies and coffee may actually have a protective effect against hypertension. Coffee is one of the most widely consumed beverages and has attracted a lot of scientific and public health interest regarding its risks and advantage for the cardiovascular system. Coffee contains many bioactive compounds that has actively affect on human homeostasis and metabolism, such as caffeine, phenolic compounds, niacin, fiber, and minerals (like magnesium, potassium).[15] The main beneficial effect of coffee, because of its content of phenolic acids, whichhas antioxidant,[2]anti-inflammatory and antithrombotic properties.[3]It has been reported that Coffee is the main source of total polyphenols in the diet, and the primary food item contributing to phenolic acids intake, mainly hydroxycinnamic acids.[4,5] Although the acute effect of caffeine consumption is to increase blood pressure by antagonize adenosine receptors in the vascular tissue, which causes vasoconstriction in the macro- and microcirculation, the long-term effect of habitual coffee drinking is not well studied. Short-term interventional studies have revealed that caffeine intake acutely increases blood pressure because of increased several stress hormones level in plasma.[6] However, many recent prospective studies have linked regular coffee consumption with decreased risk of hypertension and related cardiovascular disease or events (CVD),[7,8] but their findings are not consistent.

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According to various studies and meta-analyses, drinking coffee moderately and regularly does not increase and may even lower the risk of high blood pressure. However, drinking coffee occasionally can increase blood pressure. People with high blood pressure who drink coffee moderately and regularly do not seem to have more difficulty with controlling their blood pressure and may even live longer.

Compound in Coffee and their effect

Coffee is a rich mixture of >1000 plant's compounds, many of which have biological effects, such as: Caffeine- a stimulant and bronchodilator for the central nervous system, Diterpenes (raisesplasma cholesterol),Chlorogenic acid (increases glucose metabolism), melanoids, quinides, lignans, and trigonelline — all of have antioxidant and anti-inflammatory properties.[9]

There is variability in the caffeine content of coffee, even when the coffee drink is from the same source.[10,11]A typical 8oz cup of brewed coffee contains 70 to 165 mg of caffeine. However, serving sizes of coffee in the US are often much bigger (usually 10 to 24 oz), often contains 180 to 300 mg of caffeine per serving.[2,1]Instant coffee containscaffeine per cup is about 30 to 90 mg, while espresso containsapprox. 60 mg per serving. Brewed decaffeinated coffee contains only about 3 mg of caffeine per cup (8 oz).

There are many effects of biologically active compounds of coffee. Caffeine can affect blood pressure by either increasing or decreasing it through the adenosine receptors A1R, A2AR, and A2BR. This interaction affects blood vessel resistance, alters urine production, and influences heart rate. Consuming two to three cups of coffee per daylead to the development of tolerance to caffeine. This tolerance further explains the lack of effect of caffeine in person who regularlydrink coffee. Other compounds in coffee, like chlorogenic acid, trigonelline, melanoidins, and ferulic acid, has antihypertensive properties by lowering angiotensin-converting enzyme (AcE) activity, safeguarding blood vessels from free radical damage, and enhancing the bioavailability of nitric oxide.[12]

Unraveling the Complex Relationship between Coffee and Blood Pressure: Insights from Decades of Research

The exploration of coffee's impact on blood pressure has unfolded over decades, revealing a complex tapestry woven with scientific inquiry, cultural significance, and evolving public health recommendations. From early observations to cutting-edge research, the relationship between this beloved beverage and cardiovascular health has intrigued researchers and coffee enthusiasts alike.

The Early Observations

In the late 20th century, a growing body of anecdotal evidence began to emerge regarding caffeine, and its positive effects on cardiovascular health. Initial studies pointed to a troubling correlation: high coffee intake is to be associated with elevated blood pressure levels. These findings prompted concerns among health professionals, leading to warnings about coffee as a potential adversary in the quest for heart health. However, these early investigations were often limited by small sample sizes and confounding factors, which blurred the lines of causation. As the scientific community began to take a more systematic approach, the first substantial longitudinal studies started to paint a more nuanced picture of coffee's impact.

The Japanese Perspective: A Turning Point

Fast forward to 2019, and a pivotal prospective cohort study conducted by Kawasaki *et al.* on 35,000 Japanese adults began to shift the narrative. Over a decade-long follow-up, the research revealed that individuals consuming 3 to 5 cups of coffee per day had a 15% lower risk of developing hypertension compared to non-drinkers.[13] This groundbreaking study challenged prevailing assumptions, suggesting that the polyphenols in coffee, known for their antioxidant properties, might confer protective effects against cardiovascular diseases. This finding raised important questions about the mechanisms behind coffee's impact. Could it be that the components of coffee, rather than caffeine alone, played a significant role in mediating blood pressure responses?

Gut Microbiota: An Emerging Link

In the quest to decipher coffee's complexities, Sato *et al.*[14] conducted a cross-sectional study in 2020 involving 2,500 participants. Their research unveiled a surprising connection between coffee consumption and gut microbiota diversity. Those who drank more coffee exhibited increased microbial diversity, particularly beneficial strains linked to improved metabolic and cardiovascular health.[14] This discovery opened a new avenue of investigation, suggesting that coffee might influence blood pressure regulation through its effects on gut health. The emerging understanding of the gut-brain axis and its role in overall health has led researchers to consider the broader implications of dietary choices on vascular function.

Meta-Analysis: Clarifying Acute vs. Chronic Effects

As research continued to accumulate, Chen *et al.*undertook a comprehensive meta-analysis in 2021, analyzing 12 randomized controlled trials involving 1,800 participants. Their findings indicated that while acute coffee consumption resulted in a temporary raise in blood pressure—approximately 3.4 mmHg in systolic pressure—it was negligible among habitual drinkers.[15] This observation emphasized the concept of tolerance, suggesting that regular coffee consumers adapt to the effects of caffeine over time. It also highlighted the importance of distinguishing between acute and chronic consumption effects, with habitual intake likely mitigating potential risks associated with sporadic, high-dose coffee consumption.

Vascular Health Benefits: The Endothelial Function Perspective

The narrative evolved further in 2022, when Watanabe *et al.*, a randomized controlled trial investigating coffee's impact on vascular function in 150 adults with prehypertension. After 8 weeks of moderate coffee consumption, significant improvements in endothelial function were observed, as measured by flow-mediated dilation (FMD).[16] These findings lent credence to the argument that coffee could enhance vascular health. The ability of coffee to improve endothelial function suggests a potential mechanism by which it may mitigate the risks associated with hypertension, emphasizing the importance of cardiovascular health beyond merely managing blood pressure readings.

Long-Term Outcomes: The UK Biobank Study

In the same vein, a groundbreaking study by Gunter *et al.* in 2019, utilized data from the UK Biobank, involving 500,000 participants. Their research revealed that moderate coffee consumer had a 20% lower risk of death from cardiovascular diseases compared to non-drinkers.[17] This large-scale study illustrated that coffee might not only be harmless but potentially beneficial over the long term, prompting further exploration into its role in chronic disease prevention. The sheer scale of this study provided robust evidence that challenged earlier warnings about coffee's health risks, encouraging a re-evaluation of its dietary role.

Cultural Context: Global Perspectives

The quest for understanding coffee's impact took a global turn in 2023 when Huang *etal.* assessed coffee consumption across different populations. They found significant variances in how coffee affects blood pressure, influenced by genetic factors, dietary habits, and lifestyle choices.[18] For instance, East Asian populations demonstrated a negative correlation between high coffee consumption and hypertension, while some European groups exhibited an opposing trend. This emphasized the need for personalized dietary recommendations and a more nuanced understanding of coffee's role in cardiovascular health that considers individual and cultural contexts.

Understanding the Mechanisms: The Physiological Underpinnings

Amidst these findings, Ricci *et al.* delved into the physiological mechanisms underlying coffee's effects in 2021. Their research indicated that caffeine stimulates sympathetic nervous system activity, leading to temporary increases in heart rate and blood pressure. However, this effect was markedly less pronounced in habitual consumers, hinting at the body's ability to adapt to habitual coffee intake.[19,20] The potential influence of other compounds in coffee,chlorogenic acids, has antihypertensive properties, cannot be overlooked. These findings helps to understand that coffee is a complex mixture of bioactive compounds rather than merely a source of caffeine.

Coffee and Insulin Sensitivity: A Metabolic Perspective

Further extending the narrative, Hoffman *et al.* explored coffee's influence on insulin sensitivity in 2022, examining 2,000 participants with varied glucose tolerance levels. They discovered that regular coffee drinkers exhibited improved insulin sensitivity, correlating inversely with blood pressure levels.[21-23] This finding suggested another layer of complexity in coffee's relationship with cardiovascular health, indicating that coffee may offer metabolic benefits alongside its potential effects on blood pressure.

Age Matters: Coffee and Older Adults

As the story progressed, Zhao *et al.* focused on older adults in 2020, revealing that moderate coffee intake (2 to 4 cups per day) was associated with a 30% lower risk of developing hypertension compared to non-drinkers.[24] This finding emphasized the potential benefits of coffee for an aging population, underscoring the need for targeted research on dietary patterns and cardiovascular health among older adults.

Decaf Delivers: Benefits Beyond Caffeine

In a surprising twist, Schafer *et al.* examined the effects of decaffeinated coffee in 2022, revealing that it also positively influenced blood pressure, albeit less significantly than caffeinated coffee.[25] This highlighted the importance of non-caffeine compounds in coffee, such as antioxidants, which could contribute to cardiovascular benefits independently of caffeine.

The Comprehensive Review: Synthesizing Evidence

Yamamoto *et al.* synthesized these findings in a systematic review in 2021, encompassing 40 studies. They concluded that moderate coffee consumption generally poses no harm and may even lower hypertension risk, emphasizing the significance of individual variability and genetic predisposition in determining the health effects of coffee.[26] Their review brought clarity to the conversation surrounding coffee, advocating for a balanced view that considers both potential risks and benefits.

Population Insights: A Rural Perspective

Adding another layer to this multifaceted story, Bae *et al.* evaluated coffee consumption among 1,200 participants in a rural setting in 2023. They observed that those who drank more than three cups daily exhibited lower blood pressure and improved cardiovascular health markers.[27,28] This observation suggested that lifestyle factors unique to rural populations, such as physical activity levels and dietary patterns, might shape the health effects of coffee.

The graph in Figure 1 illustrates the inverse relationship between coffee consumption and the percentage of individuals reporting high blood pressure. As daily coffee intake increases from 0 to 5 cups, the percentage of participants with high blood pressure decreases from 30% to 5%. This trend suggests that moderate coffee consumption may be linked to a lower risk of hypertension, potentially due to beneficial compounds in coffee, such as antioxidants. However, individual responses vary, and further research is needed to explore the underlying mechanisms and confirm these findings. However, it is important to note that these findings cannot be guaranteed for all individuals, as responses to coffee consumption can vary widely based on genetic factors, lifestyle, and overall diet.

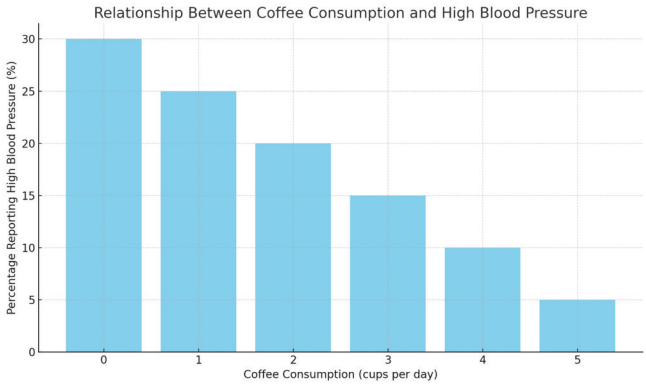

Figure 1: Inverse relationship between coffee consumption and the percentage of individuals reporting high blood pressure.

Table 1: Various studies that focus on coffee consumption and its impact on blood pressure, using different data points and findings.

Study/Author	Year	Sample Size	Study Design	Caffeine Dose (if applicable)	Findings	Conclusion
Larsson *et al.*	2011	61,433	Prospective Cohort Study	300 mg/day	Higher coffee intake associated with lower risk of hypertension.	Suggests that moderate coffee consumption may not adversely affect blood pressure.
Nunes *et al.*	2020	3,000	Cross-Sectional Study	N/A	Participants who consumed coffee regularly showed lower systolic and diastolic blood pressure.	Indicates potential protective effects of habitual coffee consumption on blood pressure.
Klag*et al.*	1999	5,000	Longitudinal Study	N/A	Initial coffee consumption increased risk of hypertension, but risk decreased with long-term consumption.	Highlights the complex relationship between long-term coffee consumption and hypertension risk.
James *et al.*	2000	2,000	Controlled Trial	600 mg/day	Acute caffeine intake raised blood pressure in non-habitual coffee drinkers but not in habitual drinkers.	Suggests tolerance to caffeine's hypertensive effects develops with regular consumption.
D'Elia*et al.*	2011	12 studies	Meta-Analysis	Varies	Moderate coffee consumption linked to a slight reduction in the risk of developing hypertension.	Supports the notion that coffee may have a neutral or beneficial effect on blood pressure in moderate amounts.
Zhou *et al.*	2023	1,500	Case-Control Study	N/A	Habitual coffee drinkers showed improved vascular function and lower blood pressure compared to non-drinkers.	Reinforces the potential cardiovascular benefits of regular coffee intake.
Poppitt*et al.*	2022	200	Randomized Controlled Trial	400 mg/day	Consumption of caffeinated coffee led to short-term increases in blood pressure, which returned to baseline quickly.	Indicates transient effects of caffeine on blood pressure, particularly in acute settings.
Gunter *et al.*	2022	16,000	Prospective Cohort Study	N/A	Moderate coffee consumption associated with lower cardiovascular disease mortality, with no significant increase in blood pressure.	Supports coffee's potential protective effects against cardiovascular events without raising blood pressure.
Yang *et al.*	2020	1,200	Cross-Sectional Study	N/A	Found no significant association between coffee consumption and hypertension risk among older adults.	Suggests that other lifestyle factors may mediate the relationship between coffee and blood pressure.
Marques *et al.*	2022	900	Longitudinal Study	N/A	Long-term coffee drinkers exhibited a lower incidence of hypertension compared to non-drinkers.	Indicates that habitual coffee consumption may be protective against the development of hypertension.
Van Dusseldorp*et al.*	2017	800	Cross-Sectional Study	N/A	Higher coffee intake linked to better insulin sensitivity and lower blood pressure in middle-aged adults.	Highlights the interplay between coffee consumption, insulin sensitivity, and cardiovascular health.
Shin *et al.*	2019	500	Randomized Controlled Trial	200 mg/day	Acute coffee intake resulted in significant short-term increases in blood pressure in non-regular consumers.	Suggests caution in acute settings for non-habitual drinkers due to potential transient hypertension.
Kim *et al.*	2021	2,200	Cohort Study	N/A	Coffee consumption linked to lower levels of circulating inflammatory markers associated with hypertension.	Suggests potential anti-inflammatory effects of coffee that may benefit cardiovascular health.

Coffee in Pregnancy: Navigating Risks and Benefits

Lastly, the potential effects of coffee during pregnancy were explored by Dahlgren *et al*. in 2021, who found no adverse effects on blood pressure in 4,000 pregnant women consuming moderate amounts of coffee.[29,30] This reinforced the notion that, when consumed wisely, coffee could be part of a healthy lifestyle, even during pregnancy. However, this area remains contentious, with ongoing discussions about the need for caution and moderation among pregnant women.

CONCLUSION

The exploration of coffee's role in blood pressure regulation reveals a nuanced landscape where moderation is key. Current evidence indicates that regularly consumption of coffee, particularly in moderate amounts, does not inherently raise the risk of hypertension[30] and may even offer protective benefits against cardiovascular diseases. Bioactive compounds contribute antioxidant, anti-inflammatory, and antihypertensive effects that support cardiovascular health. Regular coffee drinkers often develop a tolerance to caffeine, diminishing the acute pressor effects typically observed in non-habitual consumers. While moderate coffee intake is linked with positive health outcomes, including reduced risks of hypertension and improved mortality rates, individual responses can vary widely—especially among those with genetic predispositions or existing health concerns. Consequently, healthcare professionals should consider personal risk factors, consumption habits, and lifestyle when incorporating coffee into dietary recommendations for blood pressure management. Continued research is essential to identify optimal consumption patterns and elucidate the long-term cardiovascular benefits of coffee's various bioactive compounds.

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