

Exploring the relationship between coffee consumption and kidney function: A scoping review

Mengeksplorasi hubungan konsumsi kopi dengan fungsi ginjal: A scoping review

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Abstract

In recent years, dialysis has become a routine procedure for millions of patients with advanced CKD, with estimates suggesting that more than 3 million people worldwide are undergoing dialysis. This surge has been attributed to lifestyle factors, an aging population, and the increasing incidence of non-communicable diseases such as diabetes and hypertension, which are major risk factors for kidney dysfunction. One factor that is being investigated is coffee consumption as coffee consumption has increased dramatically in recent years. This scoping review aims to analyze research articles on the relationship between coffee consumption and kidney function. A total of 22 studies were identified during the database search. After excluding studies that did not meet the inclusion and exclusion criteria, 11 studies were obtained. After excluding studies that did not meet the inclusion and exclusion criteria, a total of 10 studies were obtained. The study suggests that coffee consumption has a complex relationship with kidney health. The effects of coffee consumption also depend on the amount, pattern and time of consumption, coffee components, genetics, and environmental factors. While the results suggest potential for positive outcomes, more research is needed to specifically and deeply explore these relationships and their long-term effects on human health.

Keywords: Coffee Intake, Kidney Function, Adults

Abstrak

Dalam beberapa tahun terakhir, dialisis telah menjadi prosedur rutin bagi jutaan pasien yang menderita PGK stadium lanjut, dengan perkiraan yang menunjukkan bahwa lebih dari 3 juta orang di seluruh dunia menjalani dialisis. Lonjakan ini dikaitkan dengan faktor gaya hidup, populasi yang menua, dan meningkatnya kejadian penyakit tidak menular seperti diabetes dan hipertensi, yang merupakan faktor risiko utama disfungsi ginjal. Salah satu faktor yang sedang diselidiki adalah konsumsi kopi dikarenakan konsumsi kopi sedang meningkat secara drastis beberapa tahun terakhir ini. Scoping Review ini bertujuan untuk menganalisis artikel-artikel penelitian mengenai hubungan antara konsumsi kopi dengan fungsi ginjal. Sebanyak 22 studi diidentifikasi selama pencarian basis data. Setelah mengecualikan studi yang tidak memenuhi kriteria inklusi dan eksklusi, diperoleh 11 studi. Setelah mengecualikan studi yang tidak memenuhi kriteria inklusi dan eksklusi, didapatkan total 10 studi yang diperoleh. Penelitian ini menyatakan bahwa konsumsi kopi memiliki hubungan yang kompleks dengan kesehatan ginjal. Efek konsumsi kopi juga bergantung pada jumlah, pola dan waktu konsumsi, komponen kopi, genetika, dan faktor lingkungan.

Kata Kunci: Konsumsi Kopi, Fungsi Ginjal, Dewasa

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Introduction

Coffee is among the most widely consumed beverages globally, with over 2 billion cups consumed daily. Its

popularity is attributed to its sensory appeal and bioactive compounds, particularly caffeine, which influences energy and focus. Recent trends show a significant rise in global coffee consumption, linked to its

perceived health benefits and the growing culture of coffee consumption in developing and developed regions alike. These compounds, including antioxidants, have sparked interest in their effects on chronic conditions such as kidney disease.^{1,2} While some evidence suggests that moderate coffee consumption may benefit kidney health, including slowing the decline of glomerular filtration rate (eGFR) and reducing risks of acute kidney injury (AKI), the relationship is not fully understood. Other studies have raised concerns about excessive coffee consumption in populations with genetic variations in caffeine metabolism, highlighting risks such as hypertension and albuminuria.^{1,2} The variability in findings underscores the need for comprehensive analysis of coffee's impact on kidney health.

This review aims to explore the existing evidence on coffee consumption and its relationship with kidney function, focusing on both protective effects and potential risks. By synthesizing current findings, this study seeks to provide healthcare practitioners and the public with practical guidelines regarding safe coffee consumption levels. Additionally, it identifies key areas.

Methods

This scoping review aims to analyze articles that discuss the effects of caffeine consumption in coffee on kidney function health. In addition, this observation also aims to identify areas that require further research. The search strategy and method for finding articles can be seen in Figure 1.

1. Research Questions

Can coffee affect kidney function?; How much does coffee consumption affect kidney function health?; What influences research results?

2. Identification of Relevant Studies

The articles used are from electronic journals such as PubMed and ScienceDirect. All articles used are published within the last 5 years from 2020-2024 and have unrestricted access. The articles are available in English and use Mendelian Randomization, Cohort, Observational, Cross Over design.

3. Study Selection

The titles and abstracts of the remaining records were screened for relevance by one reviewer. Full-text versions of publications identified as potentially relevant through title and abstract review were obtained, and full-text review was conducted. Full-text review was conducted by two reviewers.

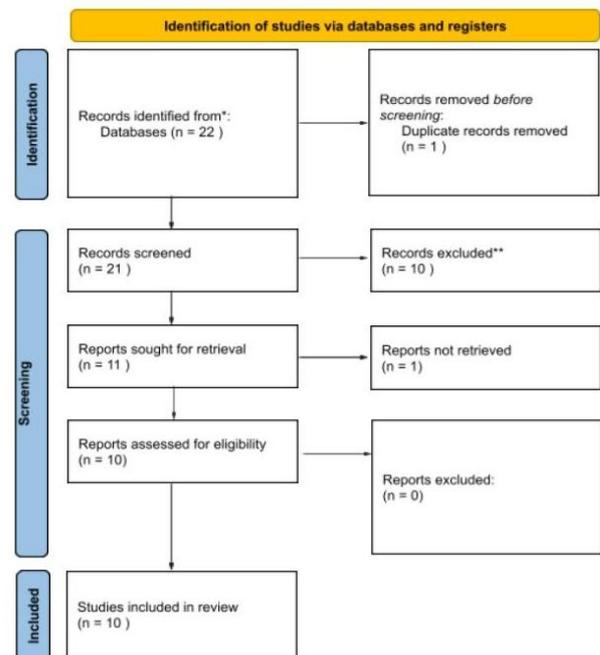
4. Charting Data

There were 22 articles were obtained from the systematic search. 11 studies were obtained. After excluding studies that did not meet the inclusion and exclusion criteria, a total of 10 studies were obtained. Then, the authors screened based on the predetermined criteria and identified the research findings related to the relationship between coffee consumption and kidney function health.

5. Object Criteria

1) research on coffee consumption on kidney health function; 2) Age range 19 years and above 3) Relevance satisfaction; 4) Publication in English; and 5) Accessibility only in free full text. The criteria for the articles were animal studies, and articles that were not related to the effect of coffee consumption on kidney health function.

Figure 1. Flow chart



Result and Discussion

Table 1. Characteristics of included studies

Author, year	Title	Country	Sample size	Study design	Participants characteristics	Result
William J. He et al. (2021)	Metabolites Associated with Coffee	United States	ARIC study: 3,811	Mendelian Randomization and	ARIC study: Mean age 54 years	20 metabolites were associated with coffee consumption,

	Consumption and Incident Chronic Kidney Disease		Bogalusa Heart Study: 1043	Prospective Cohort Study	Bogalusa Heart Study: Mean age 48 years	and three of these were associated with incident chronic kidney disease (CKD), highlighting both potential protective and harmful effects of coffee on kidney health
Yichi Chen et al. (2022)	Green tea and coffee consumption and risk of kidney cancer in Japanese adults	Japan	102463	Cohort Study	Japanese adults aged 40–69 years	No statistically significant association was found between coffee consumption and kidney cancer risk in the total population. However, in women, consuming 1–2 cups of coffee per week was associated with a significantly reduced risk of kidney cancer (HR: 0.38, 95% CI: 0.18–0.81)
A.C. van Westing, C. Ochoa-Rosales, A.C. van der Burgh et al. (2022)	Association of habitual coffee consumption and kidney function: A prospective analysis in the Rotterdam Study	Netherlands	7914	Cohort Study	Age 66 years old	Habitual coffee consumption did not significantly impact kidney function in the total study population. However, there were beneficial associations observed among high-risk groups, particularly in individuals over 70 years and those with obesity, where higher coffee consumption was linked to a slower decline in eGFR.
Díaz-López et al. (2021)	Consumption of caffeinated beverages and kidney function decline in an elderly Mediterranean population with metabolic syndrome	Spain	5851	Observational Study	Age 55 to 75 years old with obesity or metabolic syndrome	Higher intake of caffeinated coffee (>2 cups/day) and tea (≥1 cup/day) was associated with a one-year decline in estimated glomerular filtration rate (eGFR). Decaffeinated coffee was not significantly associated with changes in eGFR.

Komorita et al. (2022)	Relationship of coffee consumption with a decline in kidney function among patients with type 2 diabetes: The Fukuoka Diabetes Registry	Japan	3805	Cohort Study	Mean age 64.2 years with type 2 diabetes	Higher coffee consumption was associated with a reduced risk of eGFR decline. Compared to non-coffee drinkers, those consuming one or more cups per day had a slower annual eGFR decline.
Fujii et al. (2024)	Coffee Intake, Plasma Caffeine Levels, and Kidney Function: Two-Sample Mendelian Randomization Among East Asian and European Ancestries	Japan	1209693	Observational Study	East Asian and European ancestries	Higher coffee intake was associated with improved kidney function (eGFR) in both populations. However, elevated plasma caffeine levels were associated with lower eGFR, indicating potential adverse effects, suggesting further investigation into non-caffeine components of coffee.
Cai et al. (2024)	Coffee consumption and risk of kidney function decline in a Dutch population-base cohort	Netherlands	78346	Cohort Study	Mean age 45,8 years old	Higher coffee consumption was associated with a slower decline in estimated glomerular filtration rate (eGFR) over time, suggesting a protective association between coffee intake and kidney function decline. The effect was particularly notable among individuals with diabetes
Tommerdahl et al. (2022)	Coffee Consumption May Mitigate the Risk for Acute Kidney Injury: Results From the Atherosclerosis Risk in Communities Study	United States	14207	Cohort Study	Age 45 to 64 years old	Higher coffee intake was associated with a lower risk of acute kidney injury. Participants who drank more than two cups per day had a significantly reduced risk of AKI compared to non-coffee drinkers
Bohlen et al. (2024)	Dosimetry of human	Germany	20	Cross over design	Age 20 to 45 years old	Coffee consumption increased the urinary

	exposure to furan and 2-methylfuran by monitoring urinary biomarkers				excretion of furan and 2-methylfuran metabolites, with gender-based differences in excretion rates observed. Women tended to excrete the metabolite GSH-BDA faster than men, indicating potential sex-based metabolic differences	
Shuai et al (2021)	Coffee and Caffeine Consumption and Risk of Kidney Stones: A Mendelian Randomization Study	Sweden	UK Biobank: 6,536 cases and 388,508 non-cases FinnGen: 3,856 cases and 172,757 non-cases	Mendelian Randomization Study	Individuals of European ancestry	Genetically predicted coffee and caffeine consumption were associated with a lower risk of kidney stones. The combined odds ratio for kidney stones was 0.60 per a 50% increase in coffee consumption and 0.81 per an 80-mg increase in caffeine consumption

This scoping review shows that coffee consumption is two-sided in its effects on kidney health. Some studies indicate that moderate coffee drinking may help slow the decline in kidney function (eGFR) and reduce the risk of chronic kidney disease (CKD) and acute kidney injury (AKI). People who consume more than two cups of coffee per day tend to have a lower risk of CKD and a slower progression of kidney problems. However, this relationship is not always consistent. It has been observed that individuals who have slow metabolism of caffeine face a higher risk of developing albuminuria, hyperfiltration, and hypertension with excessive coffee consumption (more than three cups per day).

This suggests that while moderate coffee consumption may provide protective benefits, high intake may pose risks, especially for certain individuals with certain genetic factors. The results of this study showed that coffee consumption is associated with metabolites that may influence the risk of chronic kidney disease (CKD). Of the 41 metabolites associated with coffee consumption, three metabolites were found to have a significant association with CKD incidence, namely glycochenodeoxycholate, O-methylcatechol sulfate, and 3-methyl catechol sulfate. Glycochenodeoxycholate, which is involved in primary bile acid metabolism, was negatively associated with coffee consumption but positively associated with CKD

risk.³ Other studies have shown that coffee consumption is associated with a reduced risk of incident chronic kidney disease (CKD). A meta-analysis involving four cohort studies (25,849 participants) found that coffee drinkers had a lower risk of CKD compared to non-coffee drinkers (pooled risk ratio: 0.87; 95% CI: 0.81-0.95).⁴ In the study conducted by Yichi Chen et al. coffee consumption showed no significant association with kidney cancer risk in the Japanese population analyzed. This population-based cohort study included more than 102,000 participants with an average follow-up period of 19 years, which resulted in 286 cases of kidney cancer. Analysis of the data showed that coffee consumption, even at high frequencies, was not significantly associated with a reduced or increased risk of kidney cancer in either men or women.⁵ This finding is consistent with several other studies, such as the meta-analysis by Rhee et al. (2022), showing that coffee consumption has an inverse relationship with the risk of kidney cancer, specifically renal cell carcinoma. The study also showed that bioactive compounds in coffee, such as antioxidants and anti-inflammatories, may reduce oxidative stress that plays a role in cancer development. This relationship was reinforced by analysis of epidemiologic data indicating a protective effect of coffee on kidney cancer risk, noting that these results varied depending on the level of coffee consumption and other individual factors.⁶

This study from the Rotterdam Study showed that overall coffee consumption had no significant association with kidney function as measured by estimated glomerular filtration rate (eGFR) and albumin-creatinine ratio (ACR) in the general population. However, subgroup analysis showed that coffee consumption in individuals older than 70 years or with obesity was associated with an increase in eGFR during the follow-up period, indicating a potential benefit of coffee to delay renal function decline in high-risk groups. This protective effect may be due to the antioxidant and anti-inflammatory properties in coffee compounds, such as chlorogenic acid and caffeine, which have been shown to lower blood pressure and insulin resistance, major risk factors for chronic kidney disease (CKD).⁷ This result is supported by research conducted by Mazidi et al., which states that there is no significant association between coffee or caffeine consumption and kidney function or risk of chronic kidney disease (CKD). Data analysis from NHANES and meta-analysis showed that coffee consumption did not significantly affect eGFR (estimated glomerular filtration rate) or albuminuria levels. Mendelian Randomization results also found no impact of coffee consumption on CKD risk in both individuals with and without diabetes.⁸

This study examined the impact of caffeinated coffee, tea and caffeine consumption on one-year decline in renal function in an elderly population with metabolic syndrome in the Mediterranean. Based on measurements of glomerular filtration rate (eGFR), an indicator of kidney function, it was found that consumption of more than two cups of caffeinated coffee per day was associated with a more significant decrease in eGFR compared to consumption of less than one cup per day. This decrease in eGFR also applies to tea consumption of at least one cup per day. Caffeine consumption from coffee and tea also showed a similar pattern of kidney function decline, while decaffeinated coffee showed no significant effect on eGFR changes. This suggests that caffeine plays a major role in negatively affecting kidney function in vulnerable populations, especially those with obesity and metabolic syndrome.⁹

Furthermore, research conducted by Komorita et al. as part of the Fukuoka Diabetes Registry examined the relationship between coffee consumption and kidney function decline in 3,805 patients with type 2 diabetes. Over a median follow-up period of 5.3 years, participants who consumed coffee experienced a slower decline in kidney function compared to those who did not drink coffee. The group who drank two or more cups of coffee per day showed an average eGFR (estimated glomerular filtration rate) decline of 1.78 mL/min/1.73 m² per year, while those who did not drink coffee experienced an average decline of 2.16 mL/min/1.73 m² per year. After adjusting for factors such as age, gender, BMI, blood

pressure, and smoking, the analysis showed that coffee consumption was associated with a lower risk of significant eGFR decline, with a hazard ratio (HR) of 0.75 in the group with consumption of two or more cups of coffee per day. These results suggest a protective effect of coffee consumption against renal function decline in patients with type 2 diabetes.¹⁰ Another study conducted by Tang et al. had similar results, where they found an association between coffee consumption and the incidence of CKD in diabetic patients, especially in terms of the amount of consumption and time of consumption.

Overall, diabetic patients who consumed coffee throughout the day had a lower risk of CKD than those who did not. However, the effect of coffee consumption on CKD depends on the time of consumption. Diabetic patients who consumed coffee during this period had a lower risk of CKD. This risk reduction was dose-response, meaning that the higher the coffee consumption in the morning, the lower the risk of CKD. Coffee consumption at this time was associated with an increased risk of CKD. This may be due to disruption of circadian rhythm, insulin sensitivity, as well as poor sleep quality due to caffeine consumption in the evening. They offered a further explanation for the difference in results. Coffee consumption at inappropriate times, especially late afternoon into the evening, may worsen glucose tolerance, decrease insulin sensitivity, and disrupt sleep patterns. This contributes to a higher risk of CKD. In addition, they stated that coffee consumption in the morning can improve insulin sensitivity and support the body's metabolic rhythm, which helps reduce the risk of CKD and coffee also contains bioactive compounds such as caffeine, chlorogenic acid, and trigonelline, which can reduce inflammation and improve glucose and lipid metabolism.¹¹

This study used the Mendelian Randomization (MR) method to analyze the relationship of coffee consumption and plasma caffeine levels with renal function in populations of East Asian and European descent. In the East Asian population, it was found that increased coffee consumption had a protective effect against the decline in serum creatinine-based estimated glomerular filtration rate (eGFR_{cre}), with consistent results in the European population. On the other hand, higher plasma caffeine levels correlated with decreased eGFR_{cre} in both populations. These findings suggest that while coffee consumption may support kidney function, increased levels of caffeine absorbed in the body may have the opposite effect. Genetic variation also showed a consistent direction between the two populations, supporting a more comprehensive conclusion of the impact of coffee consumption on kidney health.¹² Other research suggests that although caffeine is known to have a diuretic effect, it may not directly impair kidney function in healthy individuals. However, other studies

have shown some potential benefits of coffee consumption for kidney health, such as an increase in estimated glomerular filtration rate (eGFR) or protective effects due to antioxidants.¹³

Research results from the Rotterdam Study showed that coffee consumption was not significantly associated with changes in glomerular filtration rate (eGFR) or albumin to creatinine ratio (ACR) in the general population during the 5.4-year follow-up period. However, in population subgroups at higher risk of chronic kidney disease (CKD), such as people aged over 70 years or who were obese, a positive association was found between coffee consumption and eGFR. Each increase of one cup of coffee per day was associated with an increase in eGFR by 0.84 mL/min/1.73 m² in people older than 70 years and by 0.32 mL/min/1.73 m² in those who were obese. However, there was no significant association between coffee consumption and ACR longitudinally across the population.¹⁴ Research conducted by Kanbay et al. mentioned that there was no significant difference in baseline eGFR between coffee drinkers and non-coffee drinkers. However, coffee consumption was associated with a reduced risk of incident Chronic Kidney Disease (CKD). Coffee consumption was associated with a 19% reduced risk of albuminuria (OR 0.81; *p*=0.02), and coffee drinkers had a lower risk of developing ESKD (HR 0.82; *p*=0.005). The study concluded that coffee consumption especially more than 2 cups per day, showed protective effects against CKD, ESKD, and albuminuria without significantly affecting eGFR. This is thought to be due to the antioxidant and anti-inflammatory effects of bioactive components in coffee.¹⁵

Research results from the Atherosclerosis Risk in Communities (ARIC) Study show that higher coffee consumption is associated with a lower risk of acute kidney injury (AKI). The study involved more than 14,000 adults aged 45 to 64 years, and was conducted over a median follow-up time of 24 years. The analysis found that participants who consumed 2 to 3 cups of coffee per day had a 17% reduced risk of AKI, while those who consumed more than 3 cups per day had a 12% reduced risk. This risk reduction remained significant after accounting for other factors such as age, gender, diabetes status, blood pressure, physical activity and smoking habits. The study concluded that regular coffee consumption may be a way to protect kidney health through diet.¹⁶ A related study supporting similar results involved 194,324 participants from the UK Biobank and showed that coffee consumption of 2-3 cups/day without added sugar or sweeteners was associated with a lower risk of AKI. These results applied to instant, ground, or decaffeinated coffee, with a U-shaped pattern of association, where moderate consumption provided optimal protection against AKI.¹⁷

The study showed that coffee consumption resulted in exposure to furans and 2-methylfuran (2-MF), compounds formed during coffee bean roasting and known to be toxic. In this study, 20 participants were put on a diet low in furan and 2-MF, except on two specific days where they consumed measured amounts of coffee. After coffee consumption, the levels of furan metabolites and 2-MF in urine increased significantly. The study found two peaks of metabolite excretion: one at 0-4 hours and another around 24-36 hours after coffee consumption. This suggests the possibility of enterohepatic circulation of these metabolites, where the initially excreted metabolites may be reabsorbed into the system and then re-excreted. Faster excretion of GSH-BDA in women than men was also found, indicating biological differences between the sexes in metabolizing this compound.¹⁸

This study used a Mendelian randomization (MR) approach to investigate the causal relationship between coffee and caffeine consumption and kidney stone risk. In an analysis involving data from the UK Biobank and the FinnGen consortium, it was found that genetically predicted coffee and caffeine consumption was associated with a reduced risk of kidney stones. Combined results from both data sources showed that a 50% increase in coffee consumption was associated with a reduced risk of kidney stones (odds ratio 0.60), and an 80 mg increase in caffeine consumption was associated with a similar reduced risk. Sensitivity analysis also showed that these results were consistent and showed a high level of confidence without any evidence of pleiotropy effects. This study strengthens the evidence that coffee and caffeine consumption can directly reduce the risk of kidney stones, rather than simply being the result of environmental or lifestyle-related factors.¹⁹ The results of this study are in line with a previous study by Ferraro et al. that consumption of sugar-sweetened soda and punch was associated with a higher risk of stone formation, while consumption of coffee, tea, beer, wine and orange juice was associated with a lower risk.²⁰

Conclusion

Coffee consumption has a complex relationship with kidney health, with overall risk of chronic kidney disease (CKD), kidney stones, and acute kidney injury (AKI) reduced, primarily through its bioactive compounds such as antioxidants and anti-inflammatories. These benefits are more pronounced in high-risk populations such as the elderly, obese individuals, or patients with diabetes, who exhibit slower decline in kidney function. However, the effects of coffee consumption also depend on the amount, pattern, and timing of consumption, with

excessive or occasional caffeine consumption increasing the risk of kidney disorders. While coffee is generally beneficial, there is variation in effects based on coffee components, genetics, and environmental factors, with consumption without added sugar or sweeteners likely to provide optimal results for kidney health. While the results suggest potential for positive outcomes, more research is needed to specifically and deeply explore these relationships and their long-term effects on human health.

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Authors' Contributions

Syahidah Nida Amani roles in data collection and manuscript writing and Razan Shabrina Malahati roles in the research process planning and data analysis. Almira Sitasari, Agus Wijanarka and Tri Siswati roles in writing-review and editing, supervision and project administration.

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