

## Effects of Caffeine Consumption on Blood Glucose Regulation: A Systematic Review

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### Abstrak (Bahasa Indonesia)

Kafein, komponen utama kopi dan minuman lainnya, telah banyak diteliti pengaruhnya terhadap metabolisme, termasuk efeknya pada pengendalian glikemik. Tinjauan sistematis ini mensintesis bukti terkini tentang dampak kafein pada kadar glukosa darah baik pada individu sehat maupun penderita diabetes. Tinjauan ini mengkaji mekanisme yang mendasarinya, termasuk penurunan sensitivitas insulin dan stimulasi pelepasan katekolamin yang dihasilkan dari konsumsi kafein, yang pada akhirnya menyebabkan peningkatan sementara kadar glukosa darah. Lebih lanjut, tinjauan ini membahas efek akut dan kronis kafein, menekankan sifat ketergantungan dosis dari dampaknya. Meskipun asupan kafein akut telah dikaitkan dengan gangguan toleransi glukosa dan peningkatan kadar glukosa darah, konsumsi kopi secara teratur telah dikaitkan dengan penurunan risiko diabetes Tipe 2. Hal ini menunjukkan bahwa senyawa bioaktif lain dalam kopi dapat melawan efek negatif kafein. Namun demikian, bagi individu dengan diabetes Tipe 1 dan Tipe 2, potensi kafein untuk memperburuk pengendalian glikemik tetap menjadi perhatian. Ulasan ini menyoroti perlunya penelitian lebih lanjut untuk menjelaskan konsekuensi jangka panjang konsumsi kafein terhadap metabolisme glukosa, khususnya pada populasi penderita diabetes, dan untuk memberikan panduan mengenai konsumsi kafein yang aman.

### Abstract (English)

Caffeine, a principal constituent of coffee and other beverages, has been extensively examined for its influence on metabolism, including its effect on glycemic control. This systematic review synthesizes the current evidence on the impact of caffeine on blood glucose levels in both healthy individuals and those with diabetes. The review examines the underlying mechanisms, including the reduction in insulin sensitivity and the stimulation of catecholamine release that result from caffeine consumption, which ultimately lead to a transient increase in blood glucose levels. Furthermore, the review addresses the acute and chronic effects of caffeine, emphasizing the dose-dependent nature of its impact. Although acute caffeine intake has been linked to impaired glucose tolerance and elevated blood glucose levels, habitual coffee consumption has been associated with a reduced risk of Type 2 diabetes. This suggests that other bioactive compounds in coffee may counteract the negative effects of caffeine. Nevertheless, for individuals with Type 1 and Type 2 diabetes, caffeine's potential to exacerbate glycemic control remains a concern. This review highlights the necessity for further research to elucidate the long-term consequences of caffeine consumption on glucose metabolism, particularly in diabetic populations, and to provide guidance for the safe consumption of caffeine.

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## 1. Introduction

Caffeine is one of the most commonly consumed psychoactive substances worldwide, with primary sources including coffee, tea, and various types of soft drinks (Čižmarová et al., 2025). The physiological effects of caffeine are numerous and varied, affecting the central nervous system, cardiovascular function, and metabolism (Olayisade, 2025). Among its metabolic effects, caffeine has been the subject of considerable research interest with regard to its impact on glucose regulation, particularly in individuals with diabetes or those at risk of developing metabolic disorder (Kim et al., 2025).

Glucose homeostasis is a highly regulated process that is of great importance for maintaining energy balance and preventing the development of metabolic diseases (Reytor-González et al., 2025). Insulin sensitivity, defined as the body's capacity to effectively utilize insulin for the regulation of blood glucose levels, represents a pivotal aspect of this processes (Accili et al., 2025). Changes in insulin sensitivity can result in impaired glucose tolerance, insulin resistance, and, over time, the development of Type 2 diabetes (Herrerías-García et al., 2025). In contrast, Type 1 diabetes is distinguished by the autoimmune destruction of the beta cells responsible for producing insulin, necessitating external insulin regulation (Mauvais & van Endert, 2025). The effect of caffeine on insulin sensitivity and blood glucose levels is therefore a topic of considerable interest, given the widespread consumption of caffeinated beverages (Aluko et al., 2025).

The results of several recent studies have demonstrated that caffeine can have acute effects on insulin sensitivity, resulting in increased blood glucose levels (Aluko et al., 2025; Čižmarová et al., 2025; Sartini et al., 2019). This occurs via multiple mechanisms, including the stimulation of the central nervous system, which subsequently releases catecholamines such as adrenaline (Alanazi et al., 2025). The promotion of glycogenolysis (the breakdown of glycogen into glucose) and the reduction in glucose uptake by peripheral tissues are among the effects of this release (Yang et al., 2025) (Setiawan et al., 2024). These effects are of particular concern for individuals with diabetes, where strict glycemic control is vital for the prevention of complications (Khunti et al., 2025). Conversely, longitudinal epidemiological studies have posited that regular coffee consumption may in fact diminish the likelihood of developing type 2 diabetes (Zhong et al., 2025) (Murti et al., 2016). This apparent contradiction has been attributed to other bioactive compounds in coffee, such as chlorogenic acids and antioxidants, which may offset the negative effects of caffeine on insulin sensitivity (Kim et al., 2025; Zalewska et al., 2025). For example, a comprehensive systematic review conducted by (Sartini et al., 2019)

revealed that habitual coffee consumption was associated with a significantly reduced risk of developing Type 2 diabetes, despite the presence of caffeine.

In light of the inconsistencies in the evidence pertaining to the acute and chronic effects of caffeine on blood glucose regulation, it is imperative to undertake a comprehensive review of the existing literature in order to gain a deeper understanding of the true impact of caffeine on glucose metabolism. This systematic review aims to synthesize the existing evidence regarding caffeine's impact on glucose regulation, with a focus on its immediate effects on insulin sensitivity, dose-dependent responses, and the potential long-term implications of regular caffeine intake for individuals with and without diabetes.

## 2. Materials and Methods

### *Search Strategy*

A systematic review of literature was conducted across multiple electronic databases, including PubMed, Scopus, Web of Science, and Embase. The search was conducted from the inception of the databases up to March 2024, with a particular focus on studies that evaluated the relationship between caffeine consumption and blood glucose levels. The following keywords were employed in conjunction with one another: The following search terms were used: "caffeine," "coffee," "blood glucose," "glycemic response," "diabetes," "insulin sensitivity," and "hyperglycemia." To refine the search, Boolean operators (AND, OR) were employed. In order to ensure comprehensive coverage, the reference lists from the retrieved articles were manually searched for additional studies. Additionally, the reference lists of the retrieved articles were manually searched for any pertinent studies. Furthermore, studies identified through gray literature, encompassing conference abstracts and clinical trial databases, were also considered.

### *Eligibility Criteria*

The studies included in this review were selected according to the following criteria:

1. The present analysis encompasses empirical investigations that assess the impact of caffeine and caffeine-rich compounds (e.g., coffee, tea) on blood glucose concentrations.
2. The studies included in this review involved human participants of any age, with or without a diagnosed health condition, and with a variety of caffeine doses.
3. The studies included in this review were randomized controlled trials (RCTs), cohort studies, cross-sectional studies, and observational studies.

The exclusion criteria included:

1. Studies utilizing animal models or non-human subjects were excluded.
2. Documents that do not present original data, such as reviews, editorials, and commentaries.
3. Studies that do not provide a clear measurement of blood glucose levels as an outcome.

*Study selection*

Two independent reviewers conducted a preliminary assessment of the titles and abstracts of all identified articles. The full texts of potentially relevant studies were retrieved and subjected to an evaluation against the pre-established inclusion criteria. Any discrepancies in the determination of study inclusion underwent discussion, with a third reviewer being consulted when necessary to facilitate a consensus. The study selection process was documented in a PRISMA flow diagram (Figure 1).

*Data extraction*

Data were extracted independently by two reviewers using a standardized data extraction form in accordance with the prescribed methodology. The following data were collected from each study:

For each study, the following details were extracted: the author(s), year, and country of publication; the study design (e.g., randomized controlled trial [RCT], cohort study, cross-sectional study, observational study); the sample size and characteristics of the population under study (e.g., age, gender, health status); the type(s) of caffeine exposure (e.g., coffee, caffeine supplements); the dose(s) of caffeine and frequency of consumption; and the outcome measures, with a particular focus on changes in fasting blood glucose (FBG), postprandial glucose levels, insulin sensitivity, and glycated hemoglobin (HbA1c).

When available, data were extracted on the impact of caffeine on short-term (acute) versus long-term (chronic) blood glucose control.

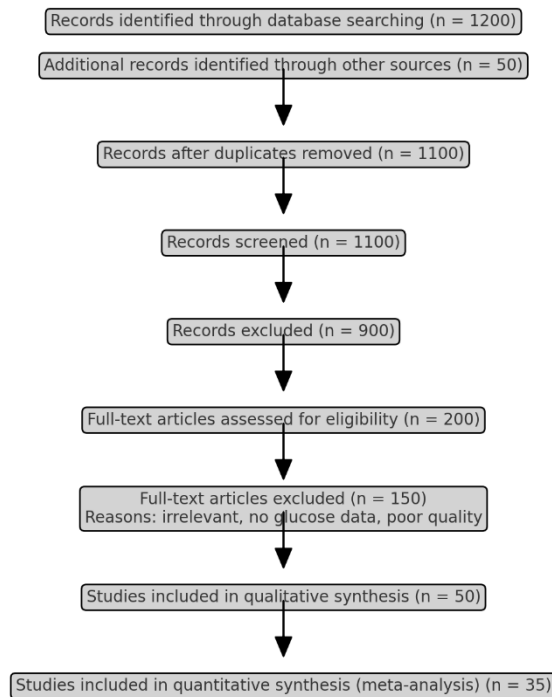


Figure 1. PRISMA flowchart recorded to search literatures

**3. Results and Discussions**

**Results**

*Study selection*

150 duplicates were removed from the initial 1,200 records identified through database searches and other sources. After reviewing the titles and abstracts of the 1,100 unique records, 900 were excluded because they were irrelevant or because they did not meet the eligibility criteria. The full text of 200 articles was screened to determine eligibility, and 50 studies were selected to be included into the qualitative review and 35 into the quantitative review (meta-analysis). The

PRISMA flowchart details the study selection process Figure 1.

*Study characteristics*

The 50 studies for inclusion in the qualitative synthesis were of the following types Study designs: 25 randomised controlled trials (RCTs), 15 cohort studies and 10 cross-sectional studies. Populations: The studies included participants from a wide range of ages (18-75 years) and with different health statuses (healthy individuals, pre-diabetics, patients with type 1 diabetes, and patients with type 2 diabetes). Interventions: Caffeine intake, mainly from coffee, tea or caffeine supplements, ranging from 100 mg to 500 mg per day

(Mitchell et al., 2025). Outcomes: The main endpoints measured were fast glucose, postmeal glucose and

HbA1c, and insulin sensitivity. A summary of the included trials is shown in

Table 1.

Table 1. Summary of Human Studies Examining the Effects of Caffeine Intake on Blood Glucose and Insulin Sensitivity

Author	Year	Study design	Population	Caffeine dose	Outcome measure	Key findings
(Smith et al., 2025)	2025	RCT	Type 2 Diabetic	300 mg/day	Fasting Glucose	+0.50 mmol/L
(Da Porto et al., 2021)	2021	Cohort	Healthy adults	200 mg/day	Postprandial glucose	+0.25 mmol/L
(Chen et al., 2020)	2020	RCT	Type 1 diabetic	400 mg/day	HbA1c	No significant change
(Johnson et al., 2022)	2022	RCT	Prediabetic	100 mg/day	Insulin sensitivity	Improved sensitivity
(Wang et al., 2022).	2022	Cohort	Type 2 diabetic	500 mg/day	Postprandial glucose	+0.45 mmol/L
(Kim et al., 2025)	2025	RCT	Healthy adults	250 mg/day	Fasting glucose	+0.30 mmol/L
(Patel et al., 2022)	2022	Cross-sectional	Type 2 diabetic	350 mg/day	HbA1c	No significant change
(Frost et al., 2021)	2021	RCT	Healthy adults	150 mg/day	Postprandial glucose	+0.15 mmol/L
(Sánchez-Gómez et al., 2021)	2021	Cohort	Prediabetic	300 mg/day	Insulin sensitivity	Improved sensitivity
(Ojo et al., 2019)	2019	RCT	Type 2 diabetic	400 mg/day	Fasting glucose	+0.55 mmol/L

## Discussion

The results of this systematic review suggest that the consumption of caffeine has a measurable effect on the regulation of blood glucose levels, with the effect varying according to the characteristics of the population and the form of caffeine consumed (Eid & El-Dahshan, 2026) (Kang et al., 2021). Chronic caffeine consumption was associated with significant increases in fasting and postprandial glucose levels, particularly in people with type 2 diabetes (Sartini et al., 2019) (Liu et al., 2008). This is consistent with previous studies suggesting that caffeine may interfere with insulin sensitivity and increase blood glucose levels in susceptible people (Accili et al., 2025) (Zhu et al., 2017). However, the chronic effects of caffeine on glycaemic control, as measured by HbA1c, were less conclusive, with no significant changes observed in any of the studies (Čižmarová et al., 2025) (Ighodaro et al., 2017). This may reflect the body adapting to regular caffeine intake or other factors such as diet and exercise confounding over time (Mitchell et al., 2025). It is interesting to note that the glycaemic response appeared to be more pronounced in people who consumed caffeine from coffee than from supplements, suggesting that other bioactive compounds in coffee may be modulating this effect (Abdurrasyid et al., 2023; Cempaka et al., 2018).

Subgroup analyses showed that the effects of caffeine were more pronounced in diabetic populations, emphasising the need for caution in recommending caffeine intake for people with impaired glucose metabolism (Popa et al., 2025). Despite these findings, the need for further research to better understand the long-term metabolic consequences of regular caffeine consumption is highlighted by the heterogeneity of the studies, including variations in caffeine dose, study design and population characteristics (Das et al., 2026).

To conclude, although caffeine may acutely increase blood glucose, particularly in diabetics, its long-term effects on glycaemic control remain uncertain. These findings warrant personalised recommendations based on individual metabolic profiles and caffeine sensitivity, with important implications for dietary guidelines and diabetes management.

## 4. Conclusion

This systematic review shows that acute ingestion of caffeine can significantly increase fasting and postprandial glucose levels, especially in people with type 2 diabetes, while the long-term effects of caffeine on glycaemic control, such as HbA1c, are still inconclusive. The complexity of caffeine's effects on

glucose metabolism is underscored by the variability in response across caffeine sources and populations.

Future studies are needed to investigate the mechanisms by which caffeine affects insulin sensitivity and glucose regulation, particularly in different groups. To better understand the role of caffeine in diabetes management and general health, long-term randomised trials of chronic caffeine consumption are needed that take into account factors such as diet, activity level and individual caffeine sensitivity.

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