Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 32s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Impact Of Caffeine and Decaffeinated Coffee on Blood Glucose Levels in Healthy Individuals And Type 2 Diabetes Patients on Antidiabetic Medication

Archana. D [1], Karthickeyan. K [2]

[1]Department of Pharmacy Practice School of Pharmaceutical Sciences, Vels Institute of Science, Technologies & Advanced Studies, Old Pallavaram, Chennai.

[2]Department of Pharmacy Practice School of Pharmaceutical Sciences, Vels Institute of Science, Technologies & Advanced Studies, Old Pallavaram, Chennai

.Cite this paper as: Archana. D , Karthickeyan. K , (2025) Impact Of Caffeine and Decaffeinated Coffee on Blood Glucose Levels in Healthy Individuals And Type 2 Diabetes Patients on Antidiabetic Medication. *Journal of Neonatal Surgery*, 14 (32s), 606-613.

ABSTRACT

Background: Coffee is among the most commonly consumed beverages worldwide, yet its effects on glycemic control remain debated. While caffeine may acutely impair insulin sensitivity, decaffeinated coffee contains bioactive compounds potentially beneficial for glucose metabolism. This randomized controlled trial aimed to assess and compare the effects of caffeinated and decaffeinated coffee on glycemic parameters in healthy individuals and patients with type 2 diabetes mellitus (T2DM) on oral antidiabetic medications.

Methods: Conducted over three months at Astra Speciality Hospital, Chennai, the study enrolled 60 participants, equally divided into two groups: Group A (healthy individuals) and Group B (T2DM patients). Each group was further randomized to receive either caffeinated or decaffeinated coffee daily. Fasting blood sugar (FBS), postprandial blood sugar (PPBS), random blood sugar (RBS), and HbA1c were recorded at baseline and at study completion.

Results: In healthy participants, caffeinated coffee led to significant increases in all glycemic markers, while decaffeinated coffee showed slight improvements. Among T2DM patients, both coffee types improved glycemic control, but the decaffeinated group exhibited significantly greater reductions, especially in HbA1c.

Conclusion: Decaffeinated coffee may support better glycemic outcomes than caffeinated coffee in both healthy individuals and those with T2DM. These findings support incorporating coffee type into personalized dietary guidance for metabolic health.

Keywords: *Caffeine; Decaffeinated coffee; Glycemic control; Type 2 diabetes mellitus; Antidiabetic medication*

1. INTRODUCTION

Caffeine, a key bioactive compound in coffee, has shown complex effects on insulin sensitivity and blood glucose regulation. Its impact varies between individuals, particularly when comparing caffeinated and decaffeinated coffee. As type 2 diabetes (T2DM) prevalence rises globally, understanding how these beverages affect blood glucose in both healthy individuals and those on antidiabetic medication is vital for informed dietary management and lifestyle interventions. Research supports the theory that coffee consumption, both caffeinated and decaffeinated, may exert beneficial effects on glucose metabolism, influencing insulin responsiveness and contributing to a lower risk of T2DM. A systematic review indicated that the beneficial effects of coffee can be attributed to several mechanisms, including the presence of antioxidants like chlorogenic acid, which may reduce oxidative stress and improve insulin sensitivity by altering glucose uptake in tissues (Reis et al., 2019; Wu et al., 2005). Additional studies suggest that decaffeinated coffee might offer a more substantial protective effect against the risk of T2DM than its caffeinated counterpart, although the mechanisms remain to be fully elucidated (Loopstra et al., 2010; (Ding et al., 2014; . This underscores the importance of distinguishing

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between the metabolic activities elicited by each type of coffee, especially regarding their implications within therapeutic diets for diabetic patients.

The role of caffeine in modulating insulin secretion and sensitivity is critical to understanding how these effects manifest in healthy individuals compared to those with impaired glucose metabolism. While acute caffeine consumption has been observed to enhance insulin secretion temporarily, prolonged exposure can result in diminished insulin sensitivity, suggesting that the body's adaptive mechanisms to caffeine intake can vary significantly depending on an individual's initial metabolic condition (Whitehead & White, 2013; Olateju et al., 2015). Furthermore, evidence indicates that caffeine's action may derive not only from its stimulatory effects but also from alterations it induces in the expression of certain metabolic enzymes, thereby influencing glycemic control (Tajima, 2013; Du et al., 2006). This duality of caffeine's metabolic effects necessitates careful consideration when evaluating dietary recommendations for individuals managing diabetes.Additionally, the metabolic response in T2DM patients often differs from that of healthy individuals, and studies have highlighted that the chronic intake of coffee may have differing effects based on an individual's specific metabolic profile. For example, habitual coffee drinkers might experience enhanced insulin sensitivity and lower fasting glucose levels, which could provide a protective effect against the development of T2DM over time (Ding et al., 2014; Shi et al., 2016). This is substantiated through meta-analyses showing a sustained inverse relationship between regular coffee consumption and the risk of developing Type 2 diabetes, reinforcing the notion that lifestyle factors, including dietary choices, play a pivotal role in the disease's progression (Urry et al., 2016; Williams et al., 2008).Understanding the physiological mechanisms underlying coffee consumption's effects necessitates a closer examination of factors including genetics and individual dietary habits, as they influence caffeine metabolism. Variability in caffeine metabolism, largely attributed to genetic polymorphisms in the cytochrome P450 1A2 enzyme, may account for the observable differences in glycemic responses among individuals (Dam et al., 2006). Furthermore, researchers have linked caffeine-induced changes in metabolic hormones, such as adiponectin, to enhanced insulin sensitivity, suggesting that personalized dietary interventions could optimize blood glucose management in diabetic patients.

2. METHODOLOGY

Study Design and Setting

This randomized controlled trial (RCT) was conducted over a period of three months at Astra Speciality Hospital, Semmancheri, Chennai, Tamil Nadu (600004). Ethical approval was obtained from the Human Institutional Ethics Committee (Ref: ECR/288/Indt/TN/2018/RR-21/122).

Sample Size and Grouping

The sample size was calculated using Rao software and determined to be 60 participants. These were randomly divided into two groups: Group A consisted of 30 healthy individuals, and Group B included 30 patients diagnosed with Type 2 Diabetes Mellitus (T2DM). The selected sample size was sufficient to provide statistically significant results.

Inclusion and Exclusion Criteria

For Group A (Healthy Individuals), inclusion criteria required participants to be aged between 18–65 years, with no history of metabolic or cardiovascular disorders, no current use of glucose metabolism-altering medications, and willingness to abstain from caffeine or coffee before the study.

For Group B (Type 2 Diabetics), participants were required to be aged 18–65 years, have a confirmed diagnosis of T2DM, and be on stable doses of antidiabetic drugs such as metformin or sulfonylureas. They were also expected to have no other metabolic disorders or recent lifestyle changes, and must be willing to refrain from caffeine or coffee prior to participation.

Exclusion criteria for healthy individuals included chronic illnesses, pregnancy or lactation, gastrointestinal absorption disorders, smoking or heavy alcohol consumption (>14 drinks/week), and the use of medications or supplements that may alter blood glucose. For diabetic participants, exclusion applied to those with recent hospitalizations, other diabetes types (e.g., Type 1), severe diabetic complications (neuropathy, retinopathy), insulin use, or pregnancy/lactation.

Study Procedure

Visit 1 (Day 1) involved obtaining written informed consent from all participants. Their demographic, medical, and surgical histories were recorded. Baseline measurements were taken, including BMI, body temperature, blood pressure, and pulse rate. Blood tests were performed to assess Random Blood Sugar (RBS), Postprandial Blood Sugar (PPBS), Fasting Blood Sugar (FBS), and Hemoglobin A1C (HbA1C). Visit 2 (Week 12) marked the end of the study. Medication compliance was reviewed using medication cards. The same set of blood tests (RBS, PPBS, FBS, HbA1C) was repeated for post-intervention comparison.

Safety Assessment

Throughout the study period, participants were monitored for any adverse events following the intervention. Any disturbances significantly impacting daily life were documented and assessed through participant interviews.

Statistical Analysis

All statistical analyses were performed using SPSS software version 26. Paired t-tests were used to compare pre- and post-intervention outcomes within each group, while independent t-tests were applied to compare outcomes between the two groups. A p-value less than 0.05 was considered statistically significant for all tests.

3. RESULTS:

Gender-wise Distribution in Healthy individuals and T2DM patients

The study population comprised two groups: healthy individuals and patients with type 2 diabetes mellitus (T2DM), each consisting of 15 participants. Among the healthy individuals, 8 were male (53.3%) and 7 were female (46.6%), reflecting a slightly male-predominant distribution. In contrast, the T2DM group included 6 males (40%) and 9 females (60%), indicating a female-predominant composition. This gender distribution suggests potential differences in the demographic profiles between the healthy and T2DM cohorts, with the T2DM group having a higher proportion of females. These differences may influence the interpretation of study outcomes, particularly if gender-related factors affect the response to the intervention or the progression of T2DM. The balanced sample size (n=15 per group) enhances the reliability of comparative analyses, though the gender disparities warrant consideration in further investigations to ensure they do not confound the results.

Overall, Distribution of Healthy and T2DM among patients based on Age

The study examined the age distribution of a total of 30 patients, comprising both healthy individuals and those with type 2 diabetes mellitus (T2DM), to understand the demographic profile across age groups. The patients were categorized into four age ranges: 31–40 years, 41–50 years, 51–60 years, and 61–70 years. The 31–40 and 41–50 age groups each included 7 patients, accounting for 23.3% of the total cohort, indicating an equal distribution in these younger and middle-age categories. The 51–60 age group was the largest, with 10 patients (33.3%), suggesting a higher prevalence of participants in this age range. The 61– 70 age group consisted of 6 patients (20%), representing the smallest proportion. This distribution highlights a concentration of patients in the 51–60 age range, which may reflect a higher incidence of T2DM or greater participation of healthy individuals in this age group. The balanced representation across age groups supports robust comparative analyses, though the predominance of the 51–60 age group may influence study outcomes and warrants consideration in interpreting the effects of interventions or disease characteristics**.**

Effects of Caffeine and Decaffeinated on RBS in Healthy Individuals: A 12-Week Comparative Study

A study comparing the effects of caffeine and decaffeinated beverages on healthy individuals over 12 weeks revealed significant changes in both groups. The caffeine group (n=unknown) had a baseline mean value of 97.7 ± 8.93, which increased to 105.3 ± 10.29 by week 12, with a statistically significant p-value of ≤ 0.0001, suggesting a notable effect of caffeine consumption. Conversely, the decaffeinated group (n=unknown) started with a baseline mean of 97.4 ± 10.08, which decreased to 95.4 ± 9.75 by week 12, also showing a significant p-value of ≤ 0.0001, indicating a distinct response to decaffeinated beverage consumption. These results highlight divergent physiological or performance outcomes between caffeine and decaffeinated interventions over the study period.

Impact of Caffeine and Decaffeinated Beverages on RBS in T2DM Patients: A 12-Week Comparative Study

A 12-week study evaluated the effects of caffeine and decaffeinated beverages on blood glucose levels in patients with type 2 diabetes mellitus (T2DM). The caffeine group (n=unknown) had a baseline mean blood glucose level of 179 ± 21.64 mg/dL, which decreased to 169.3 ± 21.70 mg/dL by week 12, with a statistically significant p-value of ≤ 0.0001, indicating a modest reduction. The decaffeinated group (n=unknown) started with a baseline mean of 174 ± 21.68 mg/dL, which significantly dropped to 144.6 ±20.65 mg/dL by week 12 (p ≤ 0.0001), suggesting a more pronounced effect of decaffeinated beverages on glucose control. These findings highlight distinct impacts of caffeine and decaffeinated interventions on glycemic management in T2DM patients

HbA1c Levels statistical Outcomes for Caffeine and Decaffeinated Groups in Healthy Individuals at Baseline and 12 Weeks

A 12-week study investigated the effects of caffeine and decaffeinated beverages on HbA1c levels in healthy individuals. The caffeine group (n=unknown) exhibited a baseline mean HbA1c of 5.13 ± 0.255%, which increased to 5.34 ± 0.30% by week 12, with a statistically significant p-value of ≤ 0.0001, suggesting a slight rise in long-term glucose levels. In contrast, the decaffeinated group (n=unknown) had a baseline mean HbA1c of 5.12 ± 0.260%,which decreased to 5.04 ± 0.250% by week 12 (p ≤ 0.0001), indicating a modest improvement in glycemic control. These results demonstrate divergent effects of caffeine and decaffeinated **beverages on HbA1c levels in healthy individuals over the study period.**

Effects of Caffeine and Decaffeinated Beverages on HbA1c Levels in T2DM Patients: A 12-Week Comparative Study

A 12-week study examined the effects of caffeine and decaffeinated beverages on HbA1c levels in patients with type 2 diabetes mellitus (T2DM). The caffeine group (n=unknown) had a baseline mean HbA1c of 7.45 ± 0.561%, which decreased to 7.1 ± 0.57% by week 12, with a statistically significant p-value of ≤ 0.0001, indicating a moderate improvement in long-term glucose control. The decaffeinated group (n=unknown) started with a baseline mean HbA1c of 7.35 ± 0.561%, which further decreased to 6.66 ± 0.539% by week 12 (p ≤ 0.0001), suggesting a more substantial improvement in glycemic control. These findings highlight that decaffeinated beverages may have a more pronounced effect on reducing HbA1c levels compared to caffeine in T2DM patients over the study period

Effects of Caffeine and Decaffeinated Beverages on Postprandial Blood Sugar Levels in Healthy Individuals: A 12-Week Comparative Study

A 12-week study assessed the impact of caffeine and decaffeinated beverages on postprandial blood sugar (PPBS) levels in healthy individuals. The caffeine group (n=unknown) had a baseline mean PPBS of 105.4± 10.41 mg/dL, which increased significantly to 121 ± 11.6 mg/dL by week 12 (p ≤ 0.0001), suggesting a notable rise in post-meal glucose levels. In contrast, the decaffeinated group (n=unknown) showed a baseline mean PPBS of 104.6 ± 11.62 mg/dL, which slightly decreased to 101.6 ± 10.97 mg/dL by week 12 (p ≤ 0.0001), indicating a modest improvement in postprandial glucose regulation. These results demonstrate contrasting effects of caffeine and decaffeinated beverages on PPBS levels in healthy individuals over the study period.

Effects of Caffeine and Decaffeinated Beverages on Postprandial Blood Sugar Levels in T2DM Patients: A 12-Week Comparative Study

A 12-week study evaluated the effects of caffeine and decaffeinated beverages on postprandial blood sugar (PPBS) levels in patients with type 2 diabetes mellitus (T2DM). The caffeine group (n=unknown) had a baseline mean PPBS of 195 ± 23.2 mg/dL, which decreased to 180.3 ± 23.2 mg/dL by week 12, with a statistically significant p-value of ≤ 0.0001, indicating a moderate reduction in post-meal glucose levels. The decaffeinated group (n=unknown) started with a baseline mean PPBS of 190 ± 23.2 mg/dL, which significantly dropped to 154 ± 21.6 mg/dL by week 12 (p ≤ 0.0001), suggesting a more substantial improvement in postprandial glucose control. These findings highlight that decaffeinated beverages may have a greater impact on reducing PPBS levels compared to caffeine in T2DM patients over the study period.

Effects of Caffeine and Decaffeinated Beverages on Fasting Blood Sugar Levels in Healthy Individuals: A 12-Week Comparative Study

A 12-week study investigated the effects of caffeine and decaffeinated beverages on fasting blood sugar (FBS) levels in healthy individuals. The caffeine group (n=unknown) had a baseline mean FBS of 87.5 ± 5.26 mg/dL, which increased significantly to 94.5 ± 6.11 mg/dL by week 12 (p ≤ 0.0001), indicating a notable rise in fasting glucose levels. In contrast, the decaffeinated group (n=unknown) had a baseline mean FBS of 87.4 ± 5.59 mg/dL, which slightly decreased to 85.26 ± 5.10 mg/dL by week 12 (p ≤ 0.0001), suggesting a modest improvement in fasting glucose regulation. These results demonstrate divergent effects of caffeine and decaffeinated beverages on FBS levels in healthy individuals over the study period. A12-week study examined the effects of caffeine and decaffeinated beverages on fasting blood sugar (FBS) levels in patients with type 2 diabetes mellitus (T2DM). The caffeine group (n=unknown) had a baseline mean FBS of 154.6 ± 17.7 mg/dL, which decreased to 144.8 ± 17.7 mg/dL by week 12, with a statistically significant p- value of ≤ 0.0001, indicating a moderate reduction in fasting glucose levels. The decaffeinated group (n=unknown) started with a baseline mean FBS of 149.6 ± 17.7 mg/dL, which significantly dropped to 122.6 ± 15.68 mg/dL by week 12 ($p \leq 0.0001$), suggesting a more substantial improvement in fasting glucose control. These findings indicate that decaffeinated beverages may have a greater impact on reducing FBS levels compared to caffeine in T2DM patients over the study period.

4. DISCUSSION:

The study population consisted of two groups: healthy individuals and patients with type 2 diabetes mellitus (T2DM), each comprising 15 participants. Among the healthy individuals, 8 were male (53.3%) and 7 were female (46.6%), indicating a slightly male-dominant composition. In contrast, the T2DM group included 6 males (40%) and 9 females (60%), reflecting a female-predominant distribution. This gender difference suggests variation in demographic characteristics between the two groups, which could potentially influence responses to the interventions administered.Regarding age distribution, participants were categorized into four age brackets: 31–40, 41–50, 51–60, and 61–70 years. The age groups of 31–40 and 41–50 each comprised 7 participants (23.3%), while the 51–60 age group had the highest representation with 10 participants (33.3%). The 61–70 age group included 6 participants (20%), representing the smallest portion. The predominance of the 51–60 age group may indicate either a higher prevalence of T2DM in this age range or greater participation willingness among middle-aged individuals.In evaluating the impact of caffeine and decaffeinated beverages on Random Blood Sugar (RBS) over 12 weeks, healthy individuals in the caffeine group showed an increase in RBS from 97.7 ± 8.93 to 105.3 ± 10.29 ($p \leq 0.0001$), while those in the decaffeinated group demonstrated a decrease from 97.4 ± 10.08 to 95.4 ± 9.75 ($p \leq 0.0001$). In T2DM patients, the caffeine group showed a modest decrease in RBS from 179 ± 21.64 to 169.3 ± 21.70 ($p \leq 0.0001$), whereas the decaffeinated group exhibited a more significant reduction from 174 ± 21.68 to 144.6 ± 20.65 ($p \leq 0.0001$).HbA1c levels in healthy individuals increased in the caffeine group from 5.13 ± 0.255% to 5.34 ± 0.30% ($p \leq 0.0001$), suggesting a slight rise in long-term glucose levels. However, the decaffeinated group showed a reduction from 5.12 ± 0.260% to 5.04 ± 0.250% ($p \leq 0.0001$), indicating improved glycemic control. Among T2DM patients, the caffeine group showed a decrease from 7.45 ± 0.561% to 7.1 ± 0.57% ($p \leq 0.0001$), while the decaffeinated group had a more substantial reduction from 7.35 ± 0.561% to 6.66 ± 0.539% ($p \leq 0.0001$), further supporting the beneficial role of decaffeinated beverages.Postprandial Blood Sugar (PPBS) levels increased in healthy individuals consuming caffeine, rising from 105.4 ± 10.41 to 121 ± 11.6 mg/dL ($p \leq 0.0001$), whereas the decaffeinated group experienced a decrease from 104.6 ± 11.62 to 101.6 ± 10.97 mg/dL ($p \leq 0.0001$). In T2DM patients, caffeine intake led to a reduction in PPBS from 195 ± 23.2 to 180.3 ± 23.2 mg/dL ($p \leq 0.0001$), while the decaffeinated group achieved a greater decrease from 190 ± 23.2 to 154 ± 21.6 mg/dL ($p \leq 0.0001$).For Fasting Blood Sugar (FBS), the caffeine group among healthy individuals showed an increase from 87.5 ± 5.26 to 94.5 ± 6.11 mg/dL ($p \leq 0.0001$), whereas the decaffeinated group experienced a slight decrease from 87.4 ± 5.59 to 85.26 ± 5.10 mg/dL ($p \leq 0.0001$). In the T2DM cohort, the caffeine group demonstrated a decrease from 154.6 ± 17.7 to 144.8 ± 17.7 mg/dL ($p \leq 0.0001$), and the decaffeinated group showed a more significant reduction from 149.6 ± 17.7 to 122.6 ± 15.68 mg/dL ($p \leq 0.0001$).

The study supports the differential impact of caffeine and decaffeinated beverages on glycemic control among healthy individuals and patients with type 2 diabetes mellitus (T2DM) over a 12-week intervention period. In healthy subjects, the findings affirm that caffeine consumption is associated with elevated random blood sugar (RBS) levels, indicating an acute hyperglycemic effect and diminished long-term glucose regulation. These observations align with previous studies suggesting that caffeine may impair insulin sensitivity and promote glucose intolerance (Shi et al., 2016; Lane et al., 2012).In contrast, the study demonstrates that decaffeinated beverages are associated with improved glycemic parameters. Specifically, participants consuming decaffeinated options showed significant reductions in both RBS and HbA1c levels. This supports earlier evidence suggesting that reducing or eliminating caffeine intake can have beneficial effects on blood sugar regulation in diabetic populations (Albar et al., 2021; Amaghani et al., 2023). Furthermore, while caffeine may produce transient reductions in glucose levels in T2DM patients, the lack of sustained benefits highlights its limited protective role compared to decaffeinated alternatives. These outcomes are consistent with the understanding that chronic caffeine consumption may hinder glucose management by impairing insulin action over time (Conde et al., 2011; Lane et al., 2012).Overall, the results suggest that decaffeinated beverages were consistently associated with improvements in RBS, PPBS, FBS, and HbA1c in both healthy and diabetic individuals, with more pronounced effects observed in T2DM patients. In contrast, caffeine consumption was associated with either neutral or adverse changes in healthy individuals and moderate improvements in T2DM patients. These findings underscore the potential of decaffeinated coffee as a more favorable intervention for glycemic management.

5. CONCLUSION:

Decaffeinated coffee may support better glycemic outcomes than caffeinated coffee in both healthy individuals and those with type 2 diabetes mellitus (T2DM). The 12-week findings revealed that decaffeinated beverages consistently improved RBS, FBS, PPBS, and HbA1c levels, while caffeine often led to elevated glucose markers in healthy individuals and only modest benefits in T2DM patients. These results underscore the importance of considering coffee type in personalized dietary guidance for metabolic health and glycemic management.

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