Research Article

Serum Calcium Levels in patients with Type 2 Diabetes Mellitus: A Hospital-Based Cross-Sectional Study in Kodagu District, Karnataka

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ABSTRACT

Background: Type 2 Diabetes Mellitus (TDM) is a chronic metabolic disorder marked by hyperglycemia. Calcium plays a crucial role in insulin secretion and glucose metabolism, yet the relationship between serum calcium levels and diabetes mellitus remains unclear, warranting further exploration.

Objective: This study aims to assess and compare serum calcium levels in T2DM patients and healthy controls in the Kodagu district, hypothesizing significant differences that could influence clinical management and public health.

Methods: Conducted from December 2022 to March 2025 at the Kodagu Institute of Medical Sciences, this hospital-based, cross-sectional study included 200 participants-100 with T2DM and 100 age-matched controls. Blood samples were collected and analyzed for serum calcium levels, fasting blood glucose and HbA1c. Statistical analyses were performed using SPSS software.

Results: Patients with T2DM had a mean serum calcium level of 8.45 ± 0.75 mg/dL, significantly lower than the 9.25 ± 0.73 mg/dL observed in controls ($p < 0.01$).

Conclusion: Decreased calcium levels in T2DM patients suggest impaired calcium homeostasis, emphasizing the need for monitoring and potential supplementation to improve glucose management strategies. Further research is needed to understand these associations better.

Keywords: Calcium, Diabetes Mellitus, Cross-Sectional Studies.

1. INTRODUCTION

Type 2 diabetes mellitus (T2DM) is widely recognised as a chronic, multifactorial metabolic disease characterized by persistent hyperglycaemia resulting from a combination of insulin resistance and relative insulin deficiency. Insulin resistance is believed to be due to varied response of cells to insulin. Over the past few decades, T2DM has emerged as a major global public health concern due to its rising prevalence and associated morbidity [1]. Contemporary statistics shows that approximately 828 million adults were living with diabetes worldwide in 2022, representing an increase of nearly 630 million cases since 1990 [2]. This dramatic rise is largely attributed to population ageing, rapid urbanisation, reduced physical activity and shifts toward increased consumption of calorie-dense diets. Importantly, T2DM is no longer confined to older populations and is increasingly being diagnosed among younger adults, thereby amplifying its long-term socioeconomic and healthcare burden [3]. Calcium is generally regarded as pivotal intracellular second messenger involved in a wide spectrum of physiological processes, including muscle contraction, neuromuscular transmission, hormone secretion, enzymatic regulation, and intracellular signalling. Within pancreatic β-cells, calcium is considered to play an important role in glucose-stimulated insulin secretion. Glucose metabolism induces membrane depolarisation, opening voltage-dependent calcium channels and facilitating calcium influx, which causes the exocytosis of insulin-containing granules [4].

This sequence of events highlights the critical role of calcium-dependent signalling pathways in the regulation of glucose-stimulated insulin secretion. In addition to its role in insulin exocytosis, calcium is increasingly recognised as regulator of multiple metabolic processes, including modulation of insulin sensitivity, adipocyte function, inflammatory signalling and cellular energy homeostasis. Disruptions in calcium handling may interfere with insulin receptor signalling, alter glucose transporter activity and favour lipid accumulation, thereby contributing to metabolic dysregulation. Accordingly, abnormalities in calcium homeostasis have been proposed as potential contributors to both the development and progression of T2DM [5]. Despite strong biological association of calcium and sugar levels, epidemiological evidence linking serum calcium levels with T2DM remains inconsistent. Several prospective cohort studies and meta-analyses have reported a positive association between higher circulating or albumin-corrected serum calcium concentrations and the risk of incident T2DM across diverse population [5, 6]. Conversely, other investigations particularly cross-sectional studies have failed to demonstrate a significant association and some have even suggested an inverse relationship between dietary calcium intake and T2DM risk. These findings may be confounded by factors such as magnesium and vitamin D status, both of which are well recognised to play important role in glucose metabolism and insulin action [7, 8]. The variability in reported findings may reflect differences in study design, population demographics, dietary habits, baseline metabolic status and the methods used for calcium assessment. These methodological variations complicate the interpretation and underscore the need for region-specific studies that account for local nutritional practices and metabolic risk profiles. India carries a substantial and rapidly increasing burden of T2DM, with a large patient load and marked regional variation in lifestyle factors and dietary intake. In many Indian populations, calcium consumption is variable and often inadequate, potentially influencing mineral metabolism and disease expression. However, region-specific studies examining serum calcium status among individuals with T2DM remain limited. The present study was therefore undertaken to compare serum calcium levels in patients with T2DM and age- and sex-matched healthy controls in the Kodagu district of Karnataka. We hypothesised that individuals with T2DM would exhibit significantly altered serum calcium concentrations compared with non-diabetic controls.

2. MATERIALS AND METHODS

2.1 Study design and setting

This hospital-based cross-sectional study was conducted at the Kodagu Institute of Medical Sciences, Madikeri, located in the Kodagu district of Karnataka, India. The study was carried out over a 27-month period from December 2022 to March 2025.

2.2 Study population

The case group comprised adults aged 30–70 years with a confirmed diagnosis of T2DM. Participants were recruited from both outpatient clinics and inpatient medical wards to ensure representation across a broad clinical spectrum. The control group consisted of apparently healthy, non-diabetic adults recruited from the general population, including patient attendants and individuals attending routine health-screening camps. Controls were matched to cases by age and sex to minimize potential demographic confounding.

2.3 Eligibility criteria

Inclusion criteria

- **T2DM group:** Adults aged 30-70 years diagnosed with T2DM according to American Diabetes Association criteria and willing to provide informed consent [9].
- **Control group:** Age- and sex-matched individuals with fasting plasma glucose <126 mg/dL and random blood glucose <140 mg/dL, with no prior history of diabetes.

Exclusion criteria Individuals with conditions known to affect calcium metabolism, including chronic kidney disease, chronic liver disease, thyroid or parathyroid disorders, were excluded. Participants receiving medications known to

influence calcium balance such as calcium or vitamin D supplements, thiazide diuretics, or systemic corticosteroids were also excluded. Pregnant or lactating women, individuals with a history of alcohol abuse, and critically ill patients were excluded to reduce confounding and ensure participant safety.

2.4 Sample size estimation

Sample size was calculated based on previously published studies evaluating serum calcium levels in individuals with T2DM in the Indian population [10]. Assuming a 1:1 case-control ratio, a two-sided alpha error of 0.05, and a statistical power of 80%, a minimum sample size of 100 participants per group was estimated to detect a clinically meaningful difference in serum calcium concentrations.

2.5 Laboratory procedures

Following a 10-12 hour overnight fast, 5 mL of venous blood was collected aseptically from the antecubital vein. Samples were allowed to clot and subsequently centrifuged at 4000 rpm for 15 minutes to obtain serum. All biochemical analyses were performed in the central laboratory of Kodagu Institute of Medical Sciences using standardised methods and internal quality control procedures.

2.6 Biochemical measurements

Serum calcium was estimated using the Arsenazo III colorimetric method on an automated analyser. Fasting blood glucose and postprandial blood glucose was measured by the glucose oxidase-peroxidase (GOD-POD) method. Renal function parameters, including serum creatinine and urea, were assessed where indicated to exclude underlying renal dysfunction.

2.7 Ethical considerations

The study protocol was approved by the Institutional Ethics Committee of Kodagu Institute of Medical Sciences. Written informed consent was obtained from all participants after explaining the study objectives, procedures, potential risks and benefits in the local language. Participant confidentiality was strictly maintained.

2.8 Statistical analysis

Statistical analysis was performed using SPSS version 23. Continuous variables were expressed as mean ± standard deviation. Differences in mean serum calcium levels between the T2DM and control groups were analysed using independent sample t-tests. A p-value of less than 0.05 was considered statistically significant.

3. RESULTS & DISCUSSION

3.1 Results

A total of 200 participants were included in the study, comprising 100 patients with T2DM and 100 age and sex matched healthy controls. In the diabetic group, there were 71 males and 29 females, whereas the control group consists of 68 males and 32 females. The majority of patients with T2DM belonged to the 51–60 year age group (Table 1).

Table 1. Demographic Characteristics of the Study Population

	Diabetic Patients (n= 100)	**Normal Subjects (n= 100)**
Age group in years		
30 - 40	11	16
41 - 50	15	21
51 - 60	46	37
61 - 70	28	26
Gender		
Male, n (%)	71 (71%)	68 (68%)
Female, n (%)	29 (29%)	32 (32%)

The diabetic group exhibited a mean fasting blood sugar (FBS) level of 140 mg/dL and a mean postprandial blood sugar (PPBS) level of 230 mg/dL. In contrast, the control group had a mean FBS of 97 mg/dL and mean PPBS of 140 mg/dL (Table 2).

Table 2. Comparison of fasting and postprandial blood glucose levels between T2DM patients and controls

	Diabetic Patients (n= 100)	**Normal Subjects (n= 100)**
Mean Fasting blood sugar (mg/dL) ± Standard deviation	142 ± 18	96 ± 12
Mean Postprandial blood sugar (mg/dL) ± Standard deviation	236 ± 26	148 ± 15

The mean serum calcium concentration in the T2DM group was 8.45 ± 0.75 mg/dL, compared with 9.25 ± 0.73 mg/dL in the control group.

Table 3: Comparison of serum calcium levels between diabetic patients and normal subjects

Group	**Mean Serum Calcium Level (mg/dL) ± Standard Deviation**	**p value**
Diabetic Patients	8.45 ± 0.75	
(n= 100)		< 0.01*
Normal Subjects	9.25 ± 0.73	
(n= 100)		

*Statistically significant at p<0.01

This difference was statistically significant ($p < 0.01$), indicating a relative reduction in serum

calcium levels among individuals with T2DM in the Kodagu district (Table 3).

3.2 Discussion

The present study is a cross sectional study conducted among individuals with type 2 diabetes mellitus (T2DM) in Kodagu District. Our study demonstrated that the mean serum calcium concentration was 8.45 ± 0.75 mg/dL, which lies within established reference ranges but trends toward the lower end of normal [11]. Although the clinical significance of lower-normal serum calcium remains uncertain, this finding suggests a potential alteration in calcium homeostasis among individuals with T2DM and warrants further investigation.

These findings are similar to several previous studies reporting reduced serum calcium levels in individuals with T2DM and support the hypothesis that altered calcium levels may influence insulin secretion and glycaemic control. Chronic hyperglycaemia may lead to calcium imbalance through increased urinary losses, impaired vitamin D metabolism and altered parathyroid hormone activity [12]. For instance, research by Nwankwor *et al.,* (2020) found a reduction in calcium levels in individuals with type 2 diabetes mellitus [13]. A study done in Indian population by Ganeshan *et al.,* (2019) reported an inverse relationship between serum calcium levels and HbA1c among patients with T2DM [14]. And cross-sectional studies done by Faysal *et al.,* (2023) and Kravchenko *et al.,* (2023) have similarly documented reduced calcium levels in diabetic population [15, 16]. These findings have been hypothesised to reflect disturbances in intracellular calcium handling, impaired insulin secretion, or altered renal calcium excretion associated with chronic hyperglycaemia. However, other studies particularly those involving well controlled diabetic populations have reported no significant differences. A study done by Itam *et al.,* (2022) observed no statistically significant difference in mean serum calcium between diabetic and non-diabetic individuals, particularly among those with well-controlled glycaemia, suggesting that metabolic control and disease duration may substantially influence calcium status [17]. In contrast, large prospective cohort studies done by Zhu *et al.,* (2021) and Yu *et al.,* (2024) have indicated associations between higher serum calcium levels and an increased risk of carotid atherosclerotic plaque and diabetic kidney disease, respectively, thereby highlighting the complicated role of calcium in glucose metabolism [18, 19]. These seemingly divergent findings likely reflect differences in study design, population characteristics, adjustment for confounding variables and temporal relationships. Variability in reported associations may suggest differences in disease duration, glycaemic control, renal function, vitamin D status, dietary calcium intake and analytical approaches to calcium measurement.

Routine monitoring of serum calcium levels is not currently a standard recommendation for all patients with T2DM [9]. From a clinical point of view, the findings suggest that assessment of serum calcium may be clinically relevant in selected patients with T2DM, particularly those with poor glycemic control, renal dysfunction, osteoporosis risk or vitamin D deficiency [20]. Current studies show that calcium supplementation alone does not consistently improve blood glucose control in T2DM, whereas combined vitamin D and calcium supplementation may provide modest metabolic benefits in selected individuals [21]. Another study showed that high dose of vitamin D supplementation was associated with modest improvements in glycemic control in obese patients with T2DM [22]. The combination of vitamin D and calcium supplementation showed improved insulin secretion, better pancreatic β-cell function and smaller rise in HbA1c [23]. Nevertheless, our cross-sectional study design precludes causal inference and the absence of data on dietary intake, vitamin D status and parathyroid hormone levels represents a key limitation.

Prospective longitudinal and interventional studies are required to outline the temporal and causal relationship between calcium homeostasis and glycaemic status. Investigations examining the impact of correcting calcium and vitamin D deficiencies on metabolic outcomes may further

elucidate the therapeutic relevance of calcium homeostasis in T2DM.

4. CONCLUSION

Our study demonstrates a statistically significant reduction in serum calcium levels among individuals with T2DM compared with healthy controls in the Kodagu district of Karnataka suggesting possible in calcium homeostasis. The findings support a potential association between varied calcium homeostasis and T2DM and indicate the importance of considering mineral metabolism in the comprehensive assessment of diabetic patients. Further studies are required to clarify causal pathways and inform targeted nutritional or therapeutic interventions.

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CONFLICT OF INTEREST

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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ETHICAL INFORMATION

The study is approved by Institutional ethics committee of Kodagu Institute of Medical Sciences, Madikeri. Written informed consent was obtained from all study participants.

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