



## Assessment of Vitamin D and Calcium Levels in Type 2 Diabetes Mellitus

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### ABSTRACT

**Introduction:** T2DM is a widely spreading metabolic disease, which is frequently related to the unregulated amounts of vitamin D and calcium. Lack of these nutrients can further deteriorate the glycemic level and exacerbate the causes of complications. **Objective:** To determine vitamin D and calcium levels in persons with T2DM and determine their connection with the evolution of the illness and control of glycemia. **Material and Methods:** The research was a cross-sectional study conducted at Aziz Fatimah Trust Hospital, Faisalabad from 15 December, 2024 to 14 June, 2025. Vitamin D and calcium levels in serum were measured in blood samples of 120 participants with ELISA and colorimetric assays. Information on HbA1c, insulin injections, and diet was also taken. **Results:** The paper identified that 29.2% of all the respondents were vitamin D-deficient, with 41.6% being calcium-deficient. The outcomes revealed a substantial negative connection between the two vitamin D and calcium levels and HbA1c. **Conclusion:** Higher severity of glycemic control in T2DM is found to be connected to a vitamin D and calcium deficiency. These gaps can be mitigated to enhance diabetes control.

### INTRODUCTION

Subsequent years were characterized by a sharp rise in the research interest on the role of vitamin D, calcium, and type 2 diabetes mellitus (T 2 DM), and many studies showed that these critical nutrients could probably lead to or affect both the development and control of the disease. T2DM is a long-lasting metabolic ailment that is characterized by insulin resistance and continuous mounting of glucose, resulting in insensitivity to glucose. Studies have documented that a significant percentage of people living with T2DM have vitamin D and calcium disturbance, a condition that aggravates the metabolic imbalance that accompanies a diagnosis of T2DM (1). With the fast escalation in the spread of T2DM in many parts of the globe, the knowledge of how such micronutrients can help prevent or manage it has become a crucial scientific area of study (2).

The most widely recognized feature of vitamin D is the regulation of calcium homeostasis and maintenance of bone health, but it also works as a modulator in the immune system and in the process of insulin release. Recent findings have indicated that, over and above their

insulin-sensitive effects in vivo, vitamin D has the capacity to affect the pathogenesis and progression of T2DM by reducing systemic inflammation, improving glycemic control, and increasing insulin sensitivity (3). Calcium also plays a key role in many physiological functions, pancreatic  $\beta$ -cell included, where it promotes the excretion of insulin in the face of increased glucose. Vitamin D and calcium deficiency can consequently worsen the metabolic factors of T2DM progression by worsening the insulin secretion and increasing insulin resistance. The relationships could show the possible importance of maximizing the status of vitamin D and calcium as one of the elements of T2DM (management). The deficiency of vitamin D is constantly noticed in persons who are subject to an elevated risk of developing T2DM, and it indicates the potential of an adequate amount of this nutrient to serve as a protective agent against diabetes (4). On the same note, Calcium, which is one of the minerals that is employed in various bodily functions, is required to be released in connection with the secretion and the action of insulin. It is essential to maintain calcium balance, as disorders of this mineral can

lead to impaired glucose metabolism. Low calcium concentrations have been previously associated with the aggravation of glycemic disorders (5). Studies on the potential effects of vitamin D treatment on a person with a diagnosis of type 2 diabetes were carried out in one or more clinical trials. To elaborate, a meta-analysis of data obtained through interventional studies found that, with regard to T2DM, the vitamin D aspect significantly influenced various biomarkers, including fasting blood glucose and HbA1c values (6). Such findings have led to the increased interest in the adoption of vitamin D treatment as an adjunct treatment for diabetics, especially among patients- with reported deficiency of the vitamin (7). Additionally, findings of some random trials have indicated that active vitamin D is effective, which validates the opinion that it could present as a potential therapeutic strategy of reducing the risk of T2DM in predisposed individuals, thereby reinforcing its clinical significance (8). The relation between calcium consumption and T2DM has also become an area of major research interest. Recent studies indicate that calcium in the diet has the potential to regulate blood glucose levels and help to minimize the possibility of contracting diabetes. Research studies have indicated that calcium intake is related to reduced insulin resistance, whereas others have theorized that supplementing calcium may positively alter metabolic variables in people with T2DM (9). Nevertheless, the potential way through which calcium affects glucose metabolism is unknown. Hypothetically, calcium can influence insulin secretion due to its involvement in the pancreatic beta-cell functioning (10, 11). Furthermore, deficiency of vitamin D is common in people with T2DM, and research indicates that patients with T2DM are even more prone to insufficient levels of this nutrient than the overall population (12). This has prompted investigations of whether insulin sensitivity and glycemic control may be enhanced by vitamin D supplementation. Studies show that low vitamin D can endanger such individuals to developing complications associated with T2DM, such as cardiovascular ailments and diabetic neuropathy (13). Surprisingly, the additional presence of other diseases, including obesity, which is very common in people with T2DM (14), can enhance the adverse effects of vitamin D deficiency. Obesity not only worsens insulin resistance but also distorts the metabolism of vitamin D in the body, which provokes a decrease in the bioavailability of the substance. This is because vitamin D is a fat-soluble vitamin, which is consequently vulnerable to getting sequestered inside adipose tissue, reducing its levels in the blood and further causing difficulties in attaining sufficient therapeutic levels when it is consumed as a supplement (15). Such impaired bioavailability becomes a major issue in the clinical treatment of T2DM because it may compromise the efficacy of vitamin D deficiency corrective measures. Besides affecting insulin sensitivity and insulin secretion, recent studies have also recognized the significance of both vitamin D and calcium in the development of risk facing formulations of getting diabetes-accompanied disorders, such as what has been denoted as cardiovascular disease, nephropathy and retinopathy and this has added more force to the aspect of

commanding thorough watchfulness and direction of their use within the diabetic populations.

Various research studies have postulated that there is a significant relationship between deficiency of vitamin D and the presence of microvascular disorders in people with T2DM, especially a higher incidence of diabetic retinopathy and nephropathy (13). The mechanisms underlying it are believed to include the effect that vitamin D has on preserving endothelial function to minimize inflammation and prevent oxidative stress, which are essential to the health of the micro vasculature. Similarly, the importance of proper calcium intake has also been debated with respect to reduced chances of possible cardiovascular complications among the T2DM patients since it can affect vascular tone, lipid metabolism, and blood pressure (16). Nevertheless, the existing evidence base is currently non-conclusive, and additional large randomized studies needed to determine the definite cause and effect. Such associations are essential to understand to inform the design of more effective and more timely treatment regimes targeting the prevention of microvascular and macro vascular complications, enhancing long-term health outcomes among people who have diabetes (T2DM) to live longer and in a healthy state. Despite the promising data, future studies are required to define how vitamin D and calcium can influence T2DM by its processes. There have been contradictory reports by other individuals, particularly in the context of the effectiveness of supplementation of vitamin D in improving glycemic control. Furthermore, the optimum supplementation quantity and period remain unknown, and clinical trials of greater value and extended period are needed to ascertain the definitive application of these nutrients in light of the treatment of T2DM (17). Furthermore, it is necessary to focus on potential vitamin D-calcium associations and how other variables such as obesity, exercise, and nutrition affect it because it also helps to determine the efficiency of supplementation.

### Objective

To find the prevalence of vitamin D and calcium in people diagnosed with type 2 diabetes mellitus and how the parameters correlated to the progression and outcome of developing the disease and managing the illness.

### MATERIALS AND METHODS

**Study Design:** Cross-Sectional Design.

**Study Setting:** This research was conducted at Aziz Fatimah Trust Hospital, Faisalabad, Pakistan.

**Duration of the Study:** The research was conducted from 15 December, 2024 to 14 June, 2025.

**Inclusion Criteria:** Participants were recruited as adult patients with type 2 diabetes, aged 40-70 years, with documented history of diabetes management who were diagnosed with the disease at least 1 year ago before date of study. Before the process every individual was made to sign an informed consent agreement.

**Exclusion Criteria:** Exclusion criteria included a medical history of chronic kidney disease, pre-existing liver tissue damage, or hyperparathyroidism, and those taking supplemental vitamin D or calcium. Other excluded persons were pregnant and lactating women.

## Methods

The participants could provide blood samples to ascertain the level of vitamin D [25(OH)D] and calcium. The availability of vitamin D was assessed using the enzyme-linked immunosorbent assay (ELISA) procedure, and the level of calcium was determined through a colorimetric process. Demographic data for the entire sample, including age, sex, and the number of years with diabetes, were documented. Some of the factors that were observed were clinical indicators of health status, like the levels of the HbA1c and insulin usage, as part of the assessment of disease control. According to the measured amounts, the respondents were divided into three categories, both in regard to vitamin D and calcium, namely, deficient, insufficient, and sufficient. Quantitative statistics using chi-square and Pearson correlation were computed to investigate the association between vitamin D and calcium levels and the clinical measures of T2DM.

## RESULTS

On the basis of the established protocol relating to the inclusion of various individuals, exactly 120 individuals were recruited under the present study, with all members having a confirmed diagnosis of type 2 diabetes mellitus (T2DM). All the participants had the qualification requirements in terms of their age range, disease history, and clinical stability, which made the study population homogenous. The selectivity in this group of participants contributed to variation reduction and increased the reliability of the data. The selection of the recruited people was well-balanced according to gender and age, and the duration of illness gave in-depth coverage of the study group. The demographic characteristics (age distribution, gender composition, and years since diagnosis) are displayed in detail in Table 1 and include the baseline demographic characterization on which future analysis is based.

**Table 1**

*Demographic Characteristics of Participants*

Characteristic	Frequency (%)	
Age (Years)	40-49	45 (37.5%)
	50-59	52 (43.3%)
	60-70	23 (19.2%)
Gender	Male	60 (50%)
	Female	60 (50%)
Duration of Diabetes (Years)	1-5	48 (40%)
	6-10	45 (37.5%)
	>10	27 (22.5%)

The serum vitamin D and calcium levels were measured and categorized according to their deficiency, insufficiency, and sufficiency status. The results for vitamin D and calcium status are shown in Table 2.

**Table 2**

*Vitamin D and Calcium Status in Participants*

Parameter	Deficient (%)	Insufficient (%)	Sufficient (%)
Vitamin D Levels	35 (29.2%)	45 (37.5%)	40 (33.3%)
Calcium Levels	50 (41.6%)	40 (33.3%)	30 (25%)

The mean serum vitamin D was discovered to be 18.5 ng/mL, which is regarded as insufficient, and calcium was,

on average, 8.3 mg/dL, implying that a substantial number of the participants had a deficiency in the quantity of calcium. The calcium status had an evident gender distinction in that males have a higher prevalence of calcium insufficiency compared to females ( $p < 0.05$ ). In the correlation analyses, a valid negative correlation was found between vitamin D levels and HbA1c, with a Pearson correlation coefficient value of  $-0.46$  ( $p < 0.01$ ), which means that the lower the vitamin D levels, the higher the HbA1c, indicating that the management of glucose is very poor. On a similar note, serum calcium and HbA1c exhibited a negative relationship ( $r = -0.38$ ,  $p < 0.05$ ), which implies that low calcium corresponded to an increase in poor glucose control in patients with T2DM. The dietary profile showed that the consumption of calcium and vitamin D among the participants was adequate and provided substantially stronger glycemic control than those who did not reach the effective levels. 60% of the participants who had adequate vitamin D had an HbA1c of less than or equal to 7%, which is the level that reflects good control of diabetes, compared to 40% of the participants who had low levels of vitamin D and were able to maintain an HbA1c of less than or equal to 7%. Moreover, the results indicated that participants with more than 10 years of type 2 diabetes were the most prevalent in terms of both vitamin D and calcium deficiency (60%). This implies a gradual loss of these vital nutrients with an increase in the duration of the disease.

**Table 3**

*Association between Vitamin D and Calcium Deficiency with HbA1c Levels*

Vitamin D Status	HbA1c $\leq$ 7% (%)	HbA1c $>$ 7% (%)
Deficient	15 (10.5%)	20 (14.4%)
Insufficient	20 (14.5%)	25 (18.6%)
Sufficient	40 (30.3%)	10 (7.5%)

In general, the findings of the present study indicate great validity in stating that the presence of vitamin D and calcium highly correlates with the management of glycemic levels amongst individuals with type 2 diabetes mellitus (T2DM). Invariably identified associations prove that these micronutrients could be one of the crucial factors in maintaining a stable blood glucose level and the potential to avoid poor metabolic outcomes. Therefore, periodical observation and early normalization of vitamin D and calcium status ought to be regarded as an inseparable part of all-inclusive approaches to managing T2DM. These actions would have the potential to improve insulin sensitivity, glucose metabolism, and decrease complications. Nevertheless, more sophisticated statistical methods and longitudinal studies should be conducted to make a clear causal connection between the mentioned nutrients and the development or progression of T2DM, which would warrant the introduction of specific clinical intervention.

## DISCUSSION

The results of the study have significant implications for the calcium and vitamin D concentrations in people with type 2 diabetes mellitus (T2DM). Negative correlation between these micronutrients and HbA1c shows strong

indications that the poorer the glycemic control, the more it drastically leads to lower serum levels of vitamin D and calcium. Excessive levels of HbA1c, which indicate a long period of hyperglycemia, were always linked to insufficiencies in these vital nutrients. Such correlation highlights the non-independent status of micronutrient status and glucose metabolism in T2DM, and this finding is congruent with a growing literature identifying the notable role of vitamin D and calcium in the management of diabetes (2,3). Vitamin D has shown various pathways in the body in which it may affect the metabolism of glucose. In addition to its classical role in mineralization of bone, vitamin D has the potential to influence the secretion of insulin through its stimulatory effect in the pancreatic beta cells, alter the immune system by inhibiting the production of inflammatory cytokines, and increase insulin sensitivity at the cellular level (4,5). A number of studies have suggested that vitamin D may bind the vitamin D receptor molecule (VDR) in the pancreatic tissue and restore the functional state of  $\beta$ -cells, which leads to an improvement in glycemic control (4,9). Moreover, the anti-inflammatory properties have suggested that vitamin D prevents chronic low-grade inflammation that often results in patients with T2DM, enhancing their metabolic conditions (12).

Calcium also plays an important role in the release of insulin. Calcium ions in pancreatic  $\beta$ -cells are one of the crucial factors leading to the release of insulin upon glucose stimulation, and sufficient availability may be a prerequisite to affect exocytosis deleteriously, whereas shortages have been suspected to inhibit the release of insulin in response to hyperglycemia (7). Calcium insufficiency was present in 41.6 percent of the sample, which was also identified in the other studies that demonstrated high rates of calcium deficiency among T2DM patients (6). It demonstrates a negative correlation between serum calcium levels and HbA1c, indicating that poor calcium intake or low circulating levels of calcium could worsen insulin resistance and degrade glycemic control. In addition, the risk of developing T2DM-associated complications like diabetic retinopathy and nephropathy has been associated with calcium deficiency (8,13). The pathophysiological mechanism might also entail the diminished insulin signaling and the direct vascular outcomes, where calcium, under consideration, is involved in the modulation of endothelial functions and vascular tone. In the current study, it has also been found that vitamin D and calcium deficiencies were more likely among such participants who had spent more than ten years living with T2DM. This result correlates with the pre-existing evidence on a link between the disease duration and increasing deterioration of the nutrients (9). It could be explained by cumulative dietary insufficiencies, metabolic changes related to the presence of chronic hyperglycemia, and, over time, a decreased efficiency of nutrient absorption. Furthermore, prolonged consumption of some antidiabetic drugs can contribute to the indirect effects on the metabolism of vitamin D and calcium (15).

One of the most interesting points of these results is the dietary intake versus glycemic control. Those who got sufficient dietary intake of calcium and vitamin D had

improved glycemic measures as seen in reduced HbA1c values. Such a finding is congruent with other research, including Rafiq and Jeppesen (10), who stated that increased calcium intakes are linked to better control of blood glucose and lesser insulin resistance amongst T2DM patients. In another study, inadequate consumption of the same nutrients was also indicated as negatively impacting glucose metabolism, which may have synergistic implications on insulin response and inflammation (13). These observations indicate that dietary intervention to achieve good levels of vitamin D and calcium can be utilized as an adjunctive intervention to manage diabetes. Supplementation may particularly help in patients who have confirmed deficiencies since daily supplementation of both vitamin D and calcium has been demonstrated to enhance insulin sensitivity as well as improve metabolic control in some populations (12). The supplementation must, nonetheless, be directed by the specific measurements to prevent hypocalcemia or vitamin D toxicity, especially among patients with comorbid conditions (like kidney disease) (15).

Despite these encouraging findings, there are a number of limitations associated with this study that need to be taken into account. To begin with, the cross-sectional type does not allow for a firm conclusion on causality. Despite the data indicating relations between the level of micronutrients and glycemic control, there is no evidence whether such deficiencies impair glycemic control or whether hyperglycemia depletes the nutrient level (17). There is a need to compare findings from longitudinal cohort studies and randomized controlled trials to determine temporal and causal relationships (3,16). Second, the confounding factors that were taken into consideration include age, gender, and duration of diabetes, but other factors that could have influenced this study might not have been addressed in a complete manner. These are body mass index (BMI), the pattern of physical activity, the sun exposure (which affects the process of endogenous vitamin D production), the socioeconomic level, and comorbid conditions (14,15). Research should better take into account a more comprehensive analytical strategy in order to control these variables in the future.

Third, a 24-hour recall method was used to collect data on the dietary intake, but this method is prone to a recall bias and cannot accurately determine the usual nutrient consumption. Underrecording or misrecording is a behavior that is characteristic of assessing diet, especially in chronically ill persons (17). A more realistic view of their nutrient intake pattern might be available if more objective long-term dietary measures, in the form of food frequency questionnaires or multi-day dietary logs, were used. The clinical concern with these results is that it is necessary to continuously review the vitamin D and calcium in T2DM patients, especially when they have crests in control or have had a long history of their disease. Finding and addressing gaps might become part of the customized plans to manage diabetes (1,6). On the part of health practitioners, dietary counseling on adequate calcium and vitamin D intakes and safe supplementation, in case of need, might be a potential measure to improve outcomes of patients (12,13).

Nevertheless, the metabolism interaction between micronutrients and glucose cannot be underestimated in its complexity. Genetic VDR function, calcium absorption efficiency, and patient variability in insulin sensitivity are among the issues that may create an individual difference in the response to dietary or supplement intervention (9,11). Consequently, though the prospect of supplementation is encouraging, there are yet to be unified clinical standards of management of vitamin D and calcium in T2DM. Current recommendations are mostly generalized based on guidelines applied in the general population, which are not suitable and specific to diabetic patients in terms of their distinct metabolic requirements (15,16). Moreover, public health interventions that would raise awareness of the importance of micronutrients in managing diabetes would be fruitful. The risk of deficiency of vitamin D and calcium in the general diabetic population could be offset via education campaigns on the consumption of food sources that are high in those nutrients (such as fatty fish, fortified dairy products, leafy greens, and fortified plant-based alternatives) (14). In people who have low exposure to the sun or individuals with diet restrictions, supplementation may represent a feasible alternative, but only when properly overseen by a medical professional.

Finally, this article confirms the notion that vitamin D and calcium are skeletal health nutrients, but crucial interventions in glucose balance and metabolism in T2DM. Their possible importance in the management of diabetes can be illustrated by the strong negative correlations with HbA1c.

Despite the fact that causation cannot be inferred in this cross-sectional study, the results may help inform this

emerging evidence base that points toward the incorporation of micronutrient monitoring and administration into regular clinical practice among diabetes patients. The areas that should be addressed in future studies are longitudinal and interventional in studies because this enables a clear understanding of optimal nutrient limits, proper supplementation plans, and the effects of correcting deficiencies over the long term in diabetes (16,17). Therefore, until that evidence is formed, the customized assessment and pertinent clinical judgment are crucial when integrating into T2DM practice strategies of vitamin D and calcium optimization.

## CONCLUSION

To sum up this study, calcium and vitamin D are highlighted as playing a great role in the management of type 2 diabetes mellitus (T2DM) as a whole. The negative nutrient levels showed greater difficulties with glucose regulation problems, whereas correcting nutrient deficiencies was found to potentially help in the overall diabetes management plan. Moreover, the results showed that vitamin D and calcium decreased significantly as their illness progressed, which indicated that it is necessary to address the situation early and intervene to stop further deterioration. Enhanced nutritional choices, safe supplementation in cases when needed, and regular check-up could help achieve better metabolic results. Nevertheless, neither causality can be established conclusively because of the cross-sectional design of the study, and additional longitudinal or interventional investigations are necessary to validate these relationships and finalize the clinical suggestions.

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