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# The Association Between Vitamin D Deficiency and Type 2 Diabetes Mellitus

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**ABSTRACT**

**Background:** Vitamin D deficiency affects 70-90% of Indians due to genetics, lifestyle, environment, and diet. It's crucial for calcium balance, insulin sensitivity, and glycemic control. However, its link to Type 2 Diabetes Mellitus (T2DM) remains inconclusive. This study aims to clarify this association. **Objectives:** This study aims to determine the prevalence of Vitamin D deficiency in T2DM patients and explore its relationship with age, gender, disease duration, glycemic control and diabetic complications. **Methodology:** A cross-sectional analytical study was conducted over two months on 100 patients from the Medicine Department at B.J. Medical College and Civil Hospital, Ahmedabad, Gujarat, India, with consent obtained. Patients diagnosed with T2DM were assessed, and their biodata and diabetes progression details were recorded, followed by a vitamin D test conducted in the biochemistry lab. **Results:** The mean age of patients with T2DM was 52.8 ± 13.957 years, with the majority being older than 35 years. Females (56%) predominated in our study. The mean vitamin D levels in the patients were 21.682 ± 14.395 ng/ml. 90% of diabetic patients had vitamin D deficiency. Vitamin D deficiency was significantly associated with increased HbA1c and fasting blood glucose levels, as well as longer diabetes duration ($p < 0.01$). Among all the complications, only microvascular were significantly associated with vitamin D deficiency ($p < 0.01$). **Conclusions:** Vitamin D could impact T2DM pathogenesis and thus screening for deficiency and further large-scale studies are recommended.

**Keywords:** Vitamin D, Type 2 diabetes mellitus, microvascular complications, vitamin D levels, vitamin D deficiency, HbA1c levels

**Introduction-**

Vitamin D is an essential nutrient for humans, which can be obtained both exogenously and endogenously. The primary source of vitamin D is endogenous synthesis by the skin with the help of ultraviolet light [1]. Vitamin D deficiency is defined as serum 25-hydroxyvitamin D levels below or equal to 30 ng/mL while levels above it are considered sufficient for humans.

According to WHO, over one billion people worldwide, including 70-90% of Indians, are vitamin D deficient due to genetic, lifestyle, environmental, and nutritional factors [1, 2]. A higher BMI increases the risk of vitamin D deficiency due to deposition in adipose tissue. Infants, lactating women, and adolescents are at higher risk due to greater vitamin D needs. Vitamin D and calcium homeostasis are important for non-skeletal outcomes such as neuromuscular function, psoriasis, multiple sclerosis, and colorectal and prostate cancer. Studies indicate vitamin D plays a key role in preventing cardiovascular diseases and cancers, inhibiting parathyroid hormone, and boosting immunity [3,4].

The incidence of Type 2 Diabetes Mellitus (T2DM) is increasing at an alarming rate both nationally and internationally [5]. Based on basic and animal studies, vitamin D has also been suspected as a modifier for diabetes risk [6]. Diabetes, linked to high morbidity and mortality from chronic renal failure and heart disease, may be influenced by correctable vitamin D deficiency [7].
Vitamin D promotes insulin sensitivity and glycemic control, and its deficiency can lead to insulin resistance, contributing to T2DM [2].
Current literature lacks sufficient evidence to support a link between T2DM and vitamin D deficiency [8]. This study aims to determine the association between vitamin D deficiency and T2DM.

**Study Hypothesis**- There is an association between vitamin D deficiency and the prevalence of Type 2 diabetes mellitus.

**Aim and Objectives**-

- To find the percentage of T2DM patients having Vitamin D deficiency.
- To explore the role of age and gender differences in vitamin D deficiency occurring in T2DM.
- To find the correlation between disease duration and glycemic control with vitamin D deficiency in T2DM.
- To find the percentage of diabetic patients with Vitamin D deficiency having acute, micro-vascular, and macro-vascular complications.

**Subject Selection Criteria-**

Inclusion criteria-

- Patients having T2DM aged between 18 to 80 years
- Both newly diagnosed patients and previously diagnosed patients of T2DM

Exclusion criteria-

- Patients with associated metabolic co-morbidities
- Pregnant patients
- Patients with active infections
- Patients on vitamin D or Multivitamin supplements

**Materials and Method**-

A cross-sectional analytical study was conducted over 2 months on 100 patients from the Medicine Department at B.J. Medical College and Civil Hospital, Ahmedabad, Gujarat, India, with patient consent obtained.

1. Patients diagnosed with T2DM according to the American Diabetes Association criteria were approached in the Medicine ward and OPD, and their biodata, and diabetes progression details were recorded.
2. A serum vitamin $D_3$ test was done in the biochemistry lab.

**Results-**

The mean age in patients with Type 2 Diabetes Mellitus (T2DM) was 52.800 ± 13.957 years. The majority of the patients were older than 35 years. The females (56%) were predominant in our study. The mean vitamin D levels in the patients were 21.682 ± 14.395 ng/ml. 90% of the T2DM patients were deficient in Vitamin D. The majority of the patients had T2DM for more than 5 years. *(Table 1)*

**TABLE 1:** Demographic and Clinical Characteristics of T2DM Patients

| **Patient Characteristics** | | |
|---|---|---|
| **Age (years)**<br>Mean ± SD = 52.800 ±13.957 | **Number of Patients** | **Percentage (%)** |
| 18-35 | 10 | 10.000 |
| 36-50 | 32 | 32.000 |
| 51-65 | 36 | 36.000 |
| 66-80 | 22 | 22.000 |
| Total | 100 | 100.000 |
| **Gender** | | |
| Female | 56 | 56.000 |
| Male | 44 | 44.000 |
| Total | 100 | 100.000 |
| **Vitamin D levels (ng/ml)**<br>Mean ± SD= 21.682 ±14.395 | | |
| Deficiency (≤ 30 ng/ml) | 90 | 90.000 |
| Sufficiency (> 30 ng/ml) | 10 | 10.000 |
| Total | 100 | 100.000 |
| **Duration of Type 2 Diabetes Mellitus (years)**<br>Mean ± SD= 7.070 ±6.012 | | |
| 5 to 10 years | 28 | 28.000 |
| Less than 5 years | 42 | 42.000 |

| | | |
|---|---|---|
| More than 10 years | 30 | 30.000 |
| Total | 100 | 100.000 |

*Table 2* presents the contingency table of vitamin D level categories in relation to HbA1c and Fasting blood glucose (FBG) levels. Among the patients, 10 were sufficient in vitamin D, and 90 were deficient. The mean HbA1c and Fasting blood glucose levels are 8.533 ± 2.551% and 169.410 ± 63.397 mg/dl respectively.

A chi-square test of independence was conducted to examine the association between vitamin D deficiency and two different diabetic indicators: HbA1c levels and FBG levels. The results indicated significant associations in both cases. For HbA1c levels, $\chi^2(1, N = 100) = 12.136$, $p < 0.01$, suggesting that vitamin D deficiency is associated with higher HbA1c levels. Similarly, for FBG levels, $\chi^2(1, N = 100) = 22.120$, $p < 0.01$, suggesting that vitamin D deficiency is associated with higher FBG levels.

**TABLE 2:** FBG and HbA1c Levels in Relation to Vitamin D Levels in T2DM patients

| | **HbA1c levels % (mmol/mol)** | | | | **Fasting blood glucose (mg/dl) levels** | | |
|---|---|---|---|---|---|---|---|
| **Vitamin D level** | **6.5% (48 mmol/mol) or more** | **Less than 6.5% (48 mmol/mol)** | **Total** | | **High (≥126 mg/dl)** | **Normal (<126 mg/dl )** | **Total** |
| Deficient (≤ 30 ng/ml) | 77 | 13 | 90 | | 80 | 10 | 90 |
| Sufficient (> 30 ng/ml) | 4 | 6 | 10 | | 3 | 7 | 10 |
| Total | 81 | 19 | 100 | | 83 | 17 | 100 |
| | P<0.01 | | | | P<0.01 | | |

*Table 3* presents the contingency table of vitamin D level categories by gender differences and age groups.

Chi-square tests revealed no significant association between vitamin D deficiency and gender differences ($\chi^2(1, N = 100) = 2.597$, $p = 0.107$) or age groups ($\chi^2(1, N = 100) = 2.609$, $p = 0.456$) among the study population.

**TABLE 3:** Gender and Age Groups in Relation to Vitamin D Levels in T2DM patients

| | **Gender** | | | | **Age groups (years)** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Vitamin D level** | **Female** | **Male** | **Total** | | **18-35** | **36-50** | **51-65** | **66-80** | **Total** |
| Deficient (≤ 30 ng/ml) | 48 | 42 | 90 | | 9 | 31 | 31 | 19 | 90 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sufficient (> 30 ng/ml) | 8 | 2 | 10 | | 1 | 1 | 5 | 3 | 10 |
| Total | 56 | 44 | 100 | | 10 | 32 | 36 | 22 | 100 |
| | p=0.107 | | | | p=0.456 | | | | |

*Table 4* presents the contingency table illustrating the distribution of patients across vitamin D categories stratified by the duration of diabetes.

A significant association was observed in the chi-square test between vitamin D levels and the duration of diabetes $\chi^2(1, N = 100) = 10.714$, $p < 0.01$, suggesting that vitamin D deficiency is significantly associated with an increase in the duration of the disease.

Notably, a higher proportion of patients with a duration of diabetes less than 5 years exhibited both deficient and sufficient vitamin D levels, while those with a duration exceeding 5 years predominantly displayed vitamin D deficiency.

**TABLE 4:** Disease duration in Relation to Vitamin D Levels in T2DM patients

| | **Disease duration groups** | | | |
|---|---|---|---|---|
| **Vitamin D levels** | **5 to 10 years** | **Less than 5 years** | **More than 10 years** | **Total** |
| Deficient (≤ 30 ng/ml) | 27 | 33 | 30 | 90 |
| Sufficient (> 30 ng/ml) | 1 | 9 | 0 | 10 |
| Total | 28 | 42 | 30 | 100 |
| | P<0.01 | | | |

The distribution of patients based on their vitamin D level categories and the presence or absence of microvascular, microvascular and acute complications is presented in *Table 5*.

Chi-square tests showed a significant association between vitamin D deficiency and microvascular complications ($\chi^2(1, N = 100) = 6.810$, $p < 0.01$), but no significant association with acute complications ($\chi^2(1, N = 100) = 0.298$, $p = 0.585$) or macrovascular complications ($\chi^2(1, N = 100) = 0.056$, $p = 0.812$) in diabetic patients.

**TABLE 5:** Distribution of T2DM Patients by Presence of Microvascular, Macrovascular, and Acute Complications and Vitamin D Levels

| | **Microvascular complications** | | | | **Acute complications** | | | | **Macrovascular complications** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Vitamin D level** | **Absent** | **Present** | **Total** | | **Absent** | **Present** | **Total** | | **Absent** | **Present** | **Total** |
| Deficient (≤ 30 ng/ml) | 52 | 38 | 90 | | 75 | 15 | 90 | | 69 | 21 | 90 |
| Sufficient (> 30 ng/ml) | 10 | 0 | 10 | | 9 | 1 | 10 | | 8 | 2 | 10 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 62 | 38 | 100 | | 84 | 16 | 100 | | 77 | 23 | 100 |
| | p<0.01 | | | | p=0.585 | | | | p=0.812 | | |

**Discussions-**

This study found a significant association between vitamin D deficiency and T2DM, consistent with previous research by Shoaib et al. [9] and Inmaculada et al. [10]. These results suggest that vitamin D influences glucose metabolism and insulin sensitivity, impacting diabetes management.

Our study showed a significant association between vitamin D deficiency and HbA1c ($p < 0.01$), consistent with findings by Buhary et al. [11] and Alqahtani et al. [12] . Despite different populations, these results support the hypothesis that vitamin D deficiency may influence glycemic control.

Our study found a significant association between vitamin D deficiency and fasting blood glucose (FBG) levels in diabetic patients ($p < 0.01$), suggesting that vitamin D status influences glycemic control. This aligns with Belle et al. [13] , who reported a similar association, but contrasts with Alkhatatbeh et al. [14], who found no significant relationship. Alkhatatbeh et al. attributed their non-significant findings by stating that the difference between the two glycemic measures is that the HbA1c reflects the average blood glucose level over the past 2–3 months while FBG represents a single measurement of blood glucose concentration following overnight fasting. As FBG is determined by the level of basal insulin secretion and HbA1c by the level of both basal and postprandial insulin secretion, the results suggest that the association between vitamin D and HbA1c could be due to vitamin D involvement in postprandial insulin secretion rather than basal insulin secretion [14]. These mixed results highlight the complexity of vitamin D's role in glucose metabolism, and further research is needed to confirm these findings and explore the underlying mechanisms.

Our research found no significant associations between age, gender, and vitamin D deficiency in T2DM patients. No studies directly comparing these factors were found, highlighting the complexity of their relationship. This lack of significant results and comparative literature underscores the multifactorial nature of these conditions and suggests that other factors may play a role, warranting further investigation.

This study explored the link between T2DM duration and vitamin D deficiency. We found a significant association indicating higher vitamin D deficiency with longer T2DM duration. This contrasts with findings by Alaidarous et al. [15], who reported an inverse relationship. Differences in study design, demographics, geographic location, and methods of assessing vitamin D deficiency may contribute to these discrepancies. Factors such as lifestyle changes and sun exposure over time could also influence vitamin D levels in diabetic populations.

Our study found a significant association between vitamin D deficiency and microvascular complications in diabetic patients, including diabetic retinopathy, nephropathy, and neuropathy. Similar associations were reported in other studies: Hong et al. [16] and Usluogullari et al. [17] linked vitamin D deficiency to diabetic nephropathy, while Xiao et al. [18] found it associated with diabetic neuropathy and foot ulcers. Lou et al. [19] also showed a strong connection between vitamin D deficiency and diabetic retinopathy. These findings highlight vitamin D's potential role in diabetic microvascular complications, likely through its effects on inflammation, endothelial function, and insulin sensitivity. Given the high prevalence of vitamin D deficiency among diabetic patients, monitoring and managing vitamin D levels could be crucial in diabetes care. Further studies are needed to explore whether vitamin D supplementation can effectively mitigate these complications.

Our study found no significant link between vitamin D deficiency and macrovascular complications or diabetic ketoacidosis (DKA) in diabetic patients. This contrasts with several studies reporting associations between vitamin D deficiency and both macrovascular complications (Yang et al. [20], Isa et al. [21], Tougaard et al. [22]) and increased DKA risk (Iqbal et al. [23], He et al. [24]). Variations in sample size, population characteristics, and study design may explain these discrepancies. Further research is needed to better understand the role of vitamin D in these aspects of diabetic health.

**Conclusions-**

In conclusion, our study highlights a significant inverse association between serum vitamin D levels and Type 2 Diabetes Mellitus (T2DM). We observed a high prevalence of vitamin D deficiency (90.0%) among T2DM patients, emphasizing its potential role in the pathogenesis and progression of the disease, particularly in relation to microvascular complications with longer disease duration. While vitamin D supplementation holds promise for preventing and managing T2DM and its complications, further large-scale studies are necessary to validate these findings conclusively. Nonetheless, healthcare providers should prioritize screening for and addressing vitamin D deficiency in individuals diagnosed with T2DM.

**Ethics:** The institutional ethics committee of B.J. Medical College issued ethical approval (Ref no. EC/Approval/47/2024/19/04/2024). The current study entitled, "The Association Between Vitamin D Deficiency and Type 2 Diabetes Mellitus" was approved for data collection. Informed consent was obtained from all patients in this study. All authors have confirmed that this study did not involve animal subjects or tissue. The authors declare that they have no conflict of interest.

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