



ORIGINAL ARTICLE

**Assessment of HbA1c and Vitamin D Levels in Type 2 Diabetes Mellitus in a Tertiary Care Hospital**

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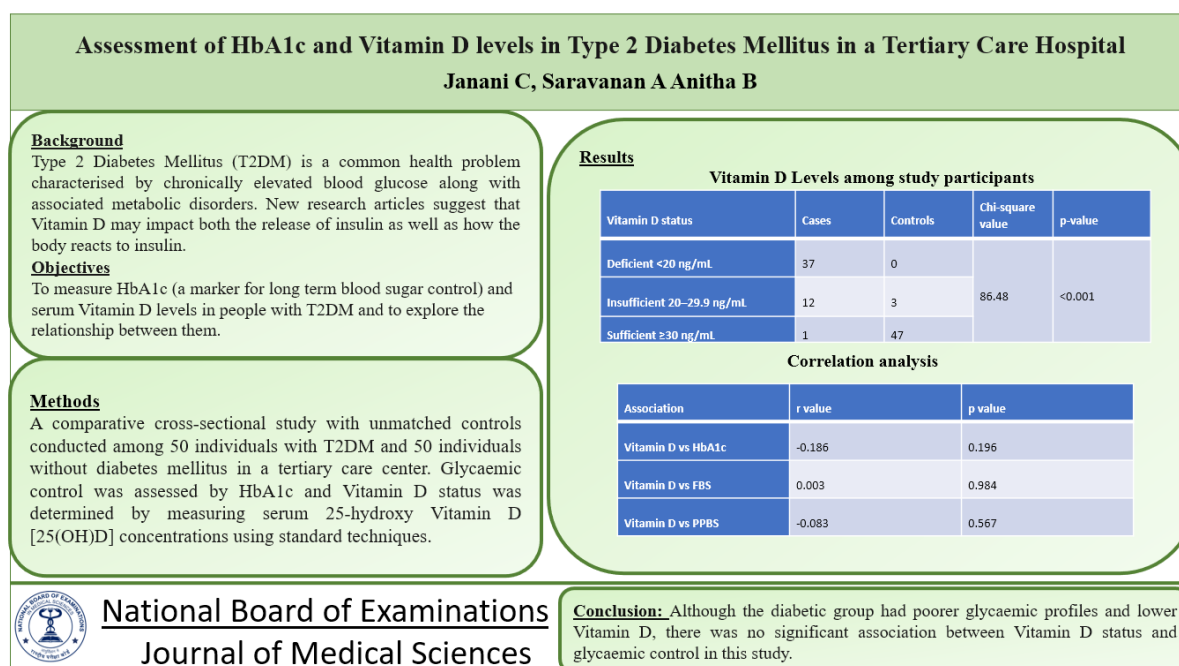
**Abstract**

**Background:** Type 2 Diabetes Mellitus (T2DM) is a common health problem characterised by chronically elevated blood glucose along with associated metabolic disorders. New research articles suggest that Vitamin D may impact both the release of insulin as well as how the body reacts to insulin. **Objective:** To measure HbA1c (a marker for long term blood sugar control) and serum Vitamin D levels in people with T2DM and to explore any relationship between them. **Materials and Methods:** A comparative cross-sectional study with unmatched controls conducted among 50 individuals with T2DM and 50 individuals without diabetes mellitus in a tertiary care center. Glycaemic control was assessed by HbA1c and Vitamin D status was determined by measuring serum 25-hydroxy Vitamin D [25(OH)D] concentrations using standard techniques. **Results:** Vitamin D levels in those with diabetes ( $17.76 \pm 5.29$  ng/mL) were significantly lower than controls ( $44.31 \pm 11.87$  ng/mL,  $p < 0.001$ ). The mean HbA1c values were also higher in the diabetic group ( $11.43 \pm 1.88\%$ ) than controls ( $5.41 \pm 0.58\%$ ,  $p < 0.001$ ). In the diabetic subjects, 74% were deficient in vitamin D. Diabetic patients also had higher levels of fasting and postprandial glucose, total cholesterol and triglycerides and lower HDL cholesterol ( $p < 0.001$ ). There was a weak negative correlation between Vitamin D and HbA1c ( $r = -0.186$ ), fasting blood sugar ( $r = 0.003$ ) and postprandial blood sugar ( $r = -0.083$ ) but these were not statistically significant. **Conclusion:** Although the diabetic group had poorer glycaemic profiles and lower Vitamin D, there was no significant association between Vitamin D status and glycaemic control in this study.

**Keywords:** Type 2 DM; Vit D Deficiency; HbA1c; 25-Hydroxy Vitamin D

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## Graphical Abstract



## Introduction

Diabetes mellitus, Type 11 (T2DM) is an important non-communicable disease worldwide and a major public health challenge in India. Diabetes is rising due to rapid urbanisation, sedentary lifestyles, changing diets, obesity, an ageing population and genetic factors. The ICMR-INDIAB study has revealed a massive burden of metabolic diseases in India, with nearly 101 million people having diabetes and 136 million having prediabetes [1].

HbA1c- Glycated haemoglobin is a well-recognised marker of glycaemic control on a long-term basis, which reflects the mean blood glucose level over the last 3 months. It is often used in diagnosis, monitoring and management of diabetes. The ADA - American Diabetes Association suggests a HbA1c threshold of 6.5% or more for the diagnosis of DM, and this marker is used to assess both treatment adequacy and the risk of chronic complications in people with diabetes [2].

Vitamin D is recognised less for its function in bone and calcium metabolism, than its extra-skeletal functions. The presence of receptors for Vitamin D in the pancreatic beta cells and other insulin responsive tissues stresses that there is a possibility of an effect on insulin secretion and sensitivity. Vitamin D may influence glucose metabolism through various mechanisms such as regulation of insulin receptor expression, promotion of calcium-mediated insulin secretion, decrease of inflammation, and enhancement of peripheral insulin sensitivity [3–5].

Vitamin D deficiency is frequently reported in individuals with T2DM. Several observational studies and systematic reviews have shown an association of lower levels of serum 25-hydroxyvitamin D with poorer glycaemic control, higher HbA1c and increased insulin resistance [6-8]. This is particularly the case in India, where, several factors such as reduced sun exposure, darker skin pigmentation,

traditional clothing, poor dietary intake and insufficient food fortification influence the Vitamin D deficiency prevalence [9].

Previous studies have shown that in T2DM patients, serum Vitamin D is inversely related to HbA1c, suggesting that those with lower Vitamin D have poorer glycaemic control [7,8]. However, results are not completely consistent because the association might be influenced by variables such as age, duration of diabetes, obesity, kidney function, medications, sunlight exposure and dietary patterns. Recent meta-analyses also suggest that Vitamin D supplementation may improve fasting blood glucose, HbA1c and insulin resistance in individuals with T2DM, though more population specific research is needed [10].

Therefore, the estimation of HbA1c and vitamin D among patients with Diabetes Mellitus (Type II) in tertiary care hospitals is of clinical significance. This approach can help to estimate the Vitamin D deficiency prevalence and examine their relationship with glycaemic control which may support more comprehensive diabetes management by highlighting modifiable nutritional factors.

### ***Aim***

To evaluate HbA1c levels and serum Vitamin D in patients with Type 2 Diabetes Mellitus in a tertiary care hospital.

### ***Objectives***

- To assess the levels of HbA1C and Vitamin D among patients with and without T2DM.
- To assess the relationship between serum Vitamin D levels and glycaemic status (HbA1c) in patients with and without T2DM.

## **Methodology**

### ***Study Design***

A comparative cross-sectional study with unmatched controls was done in the Department of Biochemistry in a tertiary care teaching hospital in Salem.

### ***Study Setting***

Participants were recruited from the Diabetology and General Medicine outpatient clinics and among the inpatients at Government Mohan Kumaramangalam Medical College Hospital, Salem.

### ***Study Period***

Data collection was conducted from April 2020 to September 2020.

### ***Study Population***

The study population included the adult patients diagnosed with Type 2 Diabetes Mellitus who visited the tertiary care hospital during the study period and non-Diabetic visitors accompanying the study recruits.

### ***Inclusion Criteria***

Adults aged 30 or above.

With established Diagnosis as Diabetes Mellitus (Type II) according to ADA Criteria [1].

Willing to participate and give written informed consent.

### ***Exclusion Criteria***

Type I Diabetes Mellitus

Pregnancy

Vitamin D supplements in the past 6 months.

Chronic kidney or liver disease.

Known malabsorption syndromes.

Concurrent intake of medications known to have interactions with metabolism of Vitamin D (e.g.,

anticonvulsants, glucocorticoids, anti-tubercular drugs).

### **Sample Size**

A convenient sample of 50 patients with Type 2 Diabetes Mellitus who fulfilled the inclusion criteria was recruited during the study period. The control group comprised 50 accompanying caregivers/attendants or visitors of patients attending the hospital who had no prior diagnosis of diabetes mellitus. Controls were selected concurrently during the same study period and were not matched to cases. Individuals with a history of diabetes mellitus, pregnancy, chronic liver disease, chronic kidney disease, malabsorption syndromes, recent Vitamin D supplementation, or medications known to affect Vitamin D metabolism were excluded from the control group.

### **Data collection**

After obtaining consent, demographic and clinical data including age, sex, duration of diabetes, treatment history, body mass index (BMI) and co-existing conditions were collected via a structured questionnaire.

### **Sample Collection**

An overnight fasted 5 mL blood sample was collected aseptically from each participant. Blood for estimation of HbA1c was collected in EDTA tube. Blood for estimation of Vitamin D was collected in a plain tube. Serum was separated by centrifugation and either analysed immediately or stored at  $-20^{\circ}\text{C}$  until required.

### **Laboratory Tests**

HbA1c was estimated by HPLC-High Performance Liquid Chromatography or immunoturbidimetric technique (as per laboratory standard operating procedures) [2].

Vitamin D Serum 25-hydroxy Vitamin D [25(OH)D] concentration was determined by the Chemiluminescence Immunoassay (eCLIA) method [3]

Vitamin D status was classified as follows:

Sufficient:  $\geq 30\text{ng/ml}$

Insufficient: 20-29 ng/mL

Deficient:  $< 20\text{ ng/ml}$

### **Primary Outcome**

Serum Vitamin D in patients with T2DM.

### **Secondary Outcomes**

HbA1c levels in the same patient group; correlation between Vitamin D and HbA1c values; relationship between Vitamin D deficiency and glycaemic control.

### **Statistical Analysis**

All data collected were entered into MS Excel and analysed using SPSSv16.0. Continuous variables were summarised as mean  $\pm$  standard deviation (SD) and categorical variables as counts and percentages. An independent Student's t-test was used to compare group means and a chi-square test was used for categorical variables. Statistical significance was defined as a p-value of  $< 0.05$ .

### **Results**

The mean age of the individuals with Type 2 Diabetes Mellitus (T2DM) in this study was  $48.38 \pm 8.26$  years while the mean age in the control group was  $50.66 \pm$

7.84 years. No statistically significant differences in age were found between the groups ( $p = 0.160$ ). The diabetic cohort had a higher proportion of female participants

(58.0%) compared to males (42.0%). In the control group males and females were equally represented (50% males, 50% females) (Table 1).

Table 1. Distribution of Continuous variables

Variable	Cases: Mean $\pm$ SD	Controls: Mean $\pm$ SD	p value
Age	48.38 $\pm$ 8.26	50.66 $\pm$ 7.84	0.160
FBS	161.22 $\pm$ 42.04	87.82 $\pm$ 9.76	<0.001
PPBS	233.64 $\pm$ 52.31	150.40 $\pm$ 24.42	<0.001
Total cholesterol	211.60 $\pm$ 33.05	157.54 $\pm$ 18.94	<0.001
Triglycerides	205.74 $\pm$ 67.15	115.46 $\pm$ 19.84	<0.001
HDL	23.84 $\pm$ 7.94	50.88 $\pm$ 6.97	<0.001
Vitamin D	17.76 $\pm$ 5.29	44.31 $\pm$ 11.87	<0.001
HbA1c	11.43 $\pm$ 1.88	5.41 $\pm$ 0.58	<0.001

The fasting blood sugar (FBS) levels were significantly higher in diabetic group (161.22  $\pm$  42.04 mg/dL) than in controls (87.82  $\pm$  9.76 mg/dL) and this difference was highly statistically significant ( $p < 0.001$ ). A similar trend was

observed in the post prandial blood sugar (PPBS) values, where the mean PPBS values for T2DM participants were higher (233.64  $\pm$  52.31 mg/dL) when compared to controls (150.40  $\pm$  24.42 mg/dL;  $p < 0.001$ ) (Table 2).

Table 2. Vitamin D Levels among study participants

Vitamin D status	Cases	Controls	Chi-square value	p-value
Deficient <20 ng/mL	37	0	86.48	<0.001
Insufficient 20–29.9 ng/mL	12	3		
Sufficient $\geq$ 30 ng/mL	1	47		

Lipid profile analysis revealed that T2DM subjects had higher mean total cholesterol ( $211.60 \pm 33.05$  mg/dL vs.  $157.54 \pm 18.94$  mg/dL), triglycerides ( $205.74 \pm 67.15$  mg/dL vs.  $115.46 \pm 19.84$

mg/dL) and lower HDL cholesterol ( $23.84 \pm 7.94$  mg/dL vs.  $50.88 \pm 6.97$  mg/dL) than healthy controls. All differences were significant ( $p < 0.001$ ) (Table 3).

Table 3. Correlation analysis

Association	r value	p value
Vitamin D vs HbA1c	-0.186	0.196
Vitamin D vs FBS	0.003	0.984
Vitamin D vs PPBS	-0.083	0.567

Serum Vitamin D concentrations were significantly lower in the diabetic group ( $17.76 \pm 5.29$  ng/mL) compared to controls ( $44.31 \pm 11.87$  ng/mL;  $p < 0.001$ ). The mean HbA1c was also significantly higher in diabetics ( $11.43 \pm 1.88\%$ ) than in controls ( $5.41 \pm 0.58\%$ ;  $p < 0.001$ ), confirming poor glycaemic control in the diabetic population.

Vitamin D status was deficient in 74%, insufficient in 24% and sufficient in 2% of patients with T2DM. In contrast, none of the controls were deficient, with most (94%) being sufficient in Vitamin D and 6% being insufficient. The difference in vitamin D status between groups was highly significant ( $\chi^2 = 86.48$ ,  $p < 0.001$ ).

Correlation analysis revealed a weak negative relation between serum

Vitamin D and HbA1c among diabetic patients ( $r = -0.186$ ,  $p = 0.196$ ). Weak nonsignificant correlations were also found between Vitamin D and fasting blood sugar ( $r = 0.003$ ,  $p = 0.984$ ) and postprandial blood sugar ( $r = -0.083$ ,  $p = 0.567$ ). These findings suggest that serum Vitamin D is not significantly associated with long- or short-term glycaemic control in this study cohort.

### Discussion

In this study, T2DM patients presented significantly lower serum Vitamin D levels than controls, consistent with the previous findings of Kostoglou-Athanassiou et al. who also reported an inverse association between Vitamin D and HbA1c levels [11]. Vitamin D deficiency was found in 74% of diabetic subjects in the present study, which is in agreement with Olt's finding of a 98.3% deficiency rate in diabetic patients [12].

Mean HbA1c among diabetics in the present study ( $11.43 \pm 1.88\%$ ) was significantly higher than controls. Similar observations were also reported by Zhang et al., who reported higher HbA1c levels and a significant negative correlation between HbA1c and Vitamin D in patients with deficiency of Vitamin D [13].

In this study, we did see a weak negative correlation between Vitamin D and HbA1c, but it was not statistically significant. In the presence of a high prevalence of deficiency, Olt et al. similarly reported no significant association between Vitamin D levels and glycaemic control [12]. Similarly, Dutta et al. reported high prevalence of Vitamin D deficiency in both diabetic and non-diabetic Indian populations, but no significant association between Vitamin D and either HbA1c or

insulin resistance, in agreement with these findings [14].

In contrast, some studies such as that of Kostoglou-Athanassiou et al. showed a significant inverse association between Vitamin D and HbA1c, indicating that lower Vitamin D concentrations may be associated with poor glycaemic control [11]. Vitamin D deficiency was also an independent predictor for higher HbA1c levels after adjusting for confounders, as was found by Zhang et al. [13]. Differences in findings may be due to differences in sample size, ethnicity, obesity rates, duration of diabetes, dietary and sun exposure patterns, or other clinical characteristics.

Moreover, a significant increase in cholesterol and triglyceride levels and a significant decrease in HDL levels were observed in diabetics supporting the concept that Vitamin D deficiency is often related to metabolic perturbations and dyslipidaemia in T2DM that could elevate the overall cardiometabolic risk [13].

These observations are in line with previous evidences that reported a high prevalence of Vitamin D deficiency among T2DM patients. However, no significant association between Vitamin D and glycaemic control was found in this cohort, although a weak negative trend was observed [12,14].

Although a high prevalence of Vitamin D deficiency was observed among patients with Type 2 Diabetes Mellitus, no statistically significant correlation was found between serum Vitamin D levels and HbA1c in the present study. Several factors may explain this finding. First, the relatively small sample size may have limited the statistical power to detect a weak association. Second, glycaemic control in T2DM is influenced by multiple

factors, including duration of diabetes, medication adherence, dietary practices, obesity, physical activity, and genetic predisposition, which may have a greater impact on HbA1c than Vitamin D status alone. Third, the high prevalence of Vitamin D deficiency among diabetic participants may have reduced variability in Vitamin D levels, making it difficult to demonstrate a significant relationship. In addition, unmeasured factors such as sunlight exposure, nutritional intake, and seasonal variation in Vitamin D status may have acted as confounders. Therefore, while Vitamin D deficiency appears to be highly prevalent in individuals with T2DM, its independent influence on glycaemic control remains uncertain and warrants further investigation through larger prospective studies incorporating adjustment for potential confounding variables.

### **Conclusion**

This study showed significantly lower serum Vitamin D levels in individuals with Type 2 DM, as well as higher HbA1c, fasting and postprandial blood glucose, triglycerides, total cholesterol and lower HDL cholesterol levels when compared to healthy controls. There was a higher vitamin D deficiency prevalence in the group with diabetes, with about three-quarters of them classified as deficient. A weak inverse relationship between Vitamin D and glycaemic parameters was noted, however the association was not statistically significant. Despite a high prevalence of Vitamin D deficiency among patients with T2DM and association with poorer metabolic profiles, this study did not demonstrate a significant relationship between serum Vitamin D and glycaemic control. Larger, prospective interventional

works are required to define the role of Vitamin D in diabetes pathogenesis and management.

### **Limitations**

The study was conducted at a single tertiary care centre with a relatively small sample size, and no formal a priori sample size calculation was performed, which may have limited the power to detect modest associations between Vitamin D status and glycaemic parameters. The control group consisted of unmatched accompanying caregivers/attendants, which may have introduced selection bias, and the analyses were based on unadjusted comparisons and correlation tests; therefore, potential confounding factors such as body mass index, duration of diabetes, dietary habits, sunlight exposure, physical activity, and other metabolic variables were not accounted for. Therefore, the findings should be interpreted with caution and validated through larger prospective studies with comprehensive adjustment for potential confounders.

### **Statements and Declarations**

#### **Conflicts of interest**

The authors declare that they do not have conflict of interest.

#### **Funding**

No funding was received for conducting this study.

#### **Ethical Approval**

Ethical approval for the research was obtained from the Institutional Ethics Committee of Government Mohan Kumaramangalam Medical College and Hospital, Salem (Ref No. GMKMC&H/4341/IEC/2019-314).

### Informed Consent

Written informed consent was obtained from all participants prior to enrolment in the study.

### Authors Contributions

CJ: has contributed to the conceptualization, design of the study, literature search, data acquisition, manuscript editing and review; AS: contributed towards conceptualization, Manuscript review and editing. BA: contributed towards literature search, data analysis, manuscript writing, review and editing. CJ: Acted as the corresponding author for this.

### References

1. Anjana RM, Unnikrishnan R, Deepa M, et al. Metabolic non-communicable disease health report of India: the ICMR-INDIAB national cross-sectional study. *Lancet Diabetes Endocrinol.* 2023;11(7):474-489.
2. American Diabetes Association Professional Practice Committee. Diagnosis and classification of diabetes: Standards of Care in Diabetes—2026. *Diabetes Care.* 2026;49(Suppl 1):S27-S49.
3. Sung CC, Liao MT, Lu KC, Wu CC. Role of vitamin D in insulin resistance. *J Biomed Biotechnol.* 2012;2012:634195.
4. Contreras-Bolívar V, García-Fontana B, García-Fontana C, Muñoz-Torres M. Mechanisms involved in the relationship between vitamin D and insulin resistance: impact on clinical practice. *Nutrients.* 2021;13(10):3491.
5. Argano C, Mirarchi L, Amodeo S, et al. The role of vitamin D and its molecular bases in insulin resistance, diabetes, metabolic syndrome, and cardiovascular disease: state of the art. *Int J Mol Sci.* 2023;24(20):15485.
6. Taderegew MM, Gebremariam T, Tareke AA, Woldeamanuel GG. Vitamin D deficiency and its associated factors among patients with type 2 diabetes mellitus: a systematic review and meta-analysis. *BMJ Open.* 2023;13:e069317.
7. Salih YA, Rasool MT, Ahmed IH, Mohammed AA. Impact of vitamin D level on glycemic control in diabetes mellitus type 2 in Duhok. *Ann Med Surg.* 2021;64:102208.
8. Alqahtani RM, Alshahrani SM, Alqahtani AS, et al. The association between glycated hemoglobin and vitamin D levels in diabetic patients. *Cureus.* 2023;15(10):e46838.
9. Amrein K, Scherkl M, Hoffmann M, et al. Vitamin D deficiency 2.0: an update on the current status worldwide. *Eur J Clin Nutr.* 2020;74(11):1498-1513.
10. Chen W, Zhang Y, Liu Y, et al. Efficacy of vitamin D supplementation on glycaemic control in type 2 diabetes: a systematic review and meta-analysis. *Diabetes Obes Metab.* 2024;26(12):5483-5496.
11. Kostoglou-Athanassiou I, Athanassiou P, Gkoutouvas A, Kaldrymides P. Vitamin D and glycemic control in diabetes mellitus type 2. *Ther Adv Endocrinol Metab.* 2013;4(4):122-128.
12. Olt S. Relationship between vitamin D and glycemic control in patients with type 2 diabetes mellitus. *Int J Clin Exp Med.* 2015;8(10):19180-19183.

13. Zhang J, Ye J, Guo G, Lan Z, Li X, Pan Z, et al. The relationship between vitamin D deficiency and glycosylated hemoglobin levels in patients with type 2 diabetes mellitus. *Diabetes Metab Syndr Obes.* 2020;13:3899-3907.
14. Dutta D, Maisnam I, Shrivastava A, Sinha A, Ghosh S, Mukhopadhyay P, et al. Does vitamin D play a significant role in type 2 diabetes? *BMC Endocr Disord.* 2014;14:90.
15. Ponnambalam A, Arun M, Prabhu G. Study on the correlation between vitamin D and HbA1c in type 2 diabetes mellitus. *Int J Med Res Rev.* 2021;9(4):219-224.
16. Pandya H, Patel D. Prevalence and severity of vitamin D deficiency in patients with type 2 diabetes mellitus and its correlation with glycaemic control. *Int J Adv Med.* 2020;7(1):24-28.
17. Luo B, Wang Y, Wang X, Qin H, Zhang Y, Sun Z. The relationship between vitamin D deficiency and glycosylated hemoglobin levels in patients with type 2 diabetes mellitus. *Diabetes Metab Syndr Obes.* 2020;13:3899-3908.
18. Alqahtani RM, Alshahrani SM, Alqahtani AS, Alghamdi AA, Alzahrani AA, Alghamdi TS. The association between glycosylated hemoglobin and vitamin D levels in diabetic patients. *Cureus.* 2023;15(10):e46838.
19. Taderegew MM, Gebremariam T, Tareke AA, Woldeamanuel GG. Vitamin D deficiency and its associated factors among patients with type 2 diabetes mellitus: a systematic review and meta-analysis. *BMJ Open.* 2023;13:e069317.
20. Zhang L, Wang J, Yang Y, Dong Y. Prevalence of vitamin D deficiency among patients with type 2 diabetes mellitus and its association with glycaemic control. *Diabetes.* 2022;71(Suppl 1):178-LB.