

Original Research Article

Comparison of 25-hydroxy vitamin D with FBG and 2 hours postprandial glucose between type 2 diabetic and healthy normoglycemic individuals

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ABSTRACT

Background: Vitamin D plays a crucial role in glucose metabolism and lipid regulation. This study aimed to evaluate the association between serum vitamin D levels and glycemic as well as lipid profiles in individuals with and without type 2 diabetes mellitus (T2DM).

Methods: This cross-sectional study was conducted at the Clinical Biochemistry and Biochemistry & Cell Biology Departments of BIRDEM General Hospital, Dhaka, from July 2014 to June 2015. A total of 200 participants aged between 30 and 70 years were selected from the outpatient department, including both type 2 diabetic patients and healthy, non-diabetic individuals. Participants were divided into two groups: Group A comprised 130 type 2 diabetic patients and Group B included 70 healthy normoglycemic controls. A purposive (convenient) sampling technique was used.

Results: The mean serum 25(OH)D level was significantly lower in T2DM patients (22.37 ± 8.34 ng/ml) compared to controls (28.92 ± 10.46 ng/ml; $p < 0.001$). In the diabetic group, vitamin D levels showed significant inverse correlations with fasting glucose, HbA1c and postprandial glucose. Additionally, serum 25 (OH)D was negatively correlated with total cholesterol, LDL and triglycerides and positively with HDL cholesterol. No significant correlations were observed in the non-diabetic group.

Conclusions: Vitamin D deficiency is more prevalent in individuals with T2DM and is significantly associated with poor glycemic control and atherogenic lipid profiles. These findings highlight the potential role of vitamin D in the metabolic regulation of diabetic patients and suggest the need for further interventional studies.

Keywords: Dyslipidemia, Glycemic control, Lipid profile, Type 2 diabetes mellitus, Vitamin D, 25(OH)D

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder that expresses the intrinsic defects in insulin secretion, along with insulin resistance, to produce hyperglycemia.¹ It is a rising worldwide health problem, leading to significant medical, economic and social problems. The International Diabetes Federation estimates

that the disease burden of diabetes is growing everywhere in the world, but is disproportionately high in low- and middle-income nations, like Bangladesh.² Chronic hyperglycemia in T2DM is associated with permanent organ damage and dysfunction, especially the eyes, kidneys, nerves, heart and vessels.³ Vitamin D, traditionally linked with calcium and phosphate metabolism and bone health, has recently been gaining

interest because of its potential contribution to glucose metabolism and insulin sensitivity.⁴ The biologically active form of vitamin D, 1,25-dihydroxyvitamin D, exerts its action through interaction with the vitamin D receptor (VDR), present in a variety of tissues including pancreatic β -cells and insulin target tissues like adipose tissue and skeletal muscle.⁵ Recent evidence has shown that vitamin D deficiency may lead to impaired insulin secretion, decreased insulin sensitivity and contribute to the pathogenesis of type 2 diabetes mellitus.⁶

Several observational and epidemiological research have found a high prevalence of vitamin D deficiency among persons with T2DM, with a likely inverse association between serum 25-hydroxyvitamin D (25(OH)D) levels and fasting blood glucose (FBG), 2-hour postprandial glucose (2hPPG) and HbA1C.⁷ Vitamin D is also anti-inflammatory and has immunomodulatory effects that may have other effects on glucose metabolism and insulin sensitivity.⁸ Despite these associations, the precise association between vitamin D status and control of glycemia remains unclear due to heterogeneity of study populations, designs and confounding variables such as age, BMI, exercise, sun exposure and nutrition.⁹

In Bangladesh, where sunlight is abundant, vitamin D deficiency has been reported to be very common even there, perhaps due to lack of exposure to sun, dress codes, color of skin and dietary insufficiency.¹⁰ Furthermore, the risk of type 2 diabetes is growing very fast, thus it becomes crucial to explore potential modifiable factors like vitamin D that can affect glucose metabolism and disease process.¹¹

This study was set up to compare 25-hydroxyvitamin D status in type 2 diabetic patients and normoglycemic healthy controls and to investigate the relationship between 25(OH)D and fasting and 2-hour postprandial glucose. By investigating these values in a Bangladeshi population, this research aims to contribute to the growing evidence in relation to the potential of vitamin D in glucose metabolism. Identification of this correlation can shed light on prevention strategies and adjuvant treatments in enhancing the management of type 2 diabetes.

METHODS

This cross-sectional study was conducted at the Clinical Biochemistry and Biochemistry and Cell Biology Departments of BIRDEM General Hospital, Dhaka, from July 2014 to June 2015. A total of 200 participants aged between 30 and 70 years were selected from the outpatient department, including both type 2 diabetic patients and healthy, non-diabetic individuals. Participants were divided into two groups: Group A comprised 130 type 2 diabetic patients and Group B included 70 healthy normoglycemic controls. A purposive (convenient) sampling technique was used. Subjects were included if they were aged 30–70 years, of either sex and either diagnosed with type 2 diabetes or were healthy individuals

without diabetes. Exclusion criteria included patients taking anti-lipidemic drugs, vitamin D or calcium supplements and those with advanced liver or kidney disease, connective tissue disorders, pregnancy or lactation.

Data were collected through face-to-face interviews using a structured questionnaire that included demographic, socioeconomic and clinical information such as age, sex, physical activity, family history and BMI. Diagnosis of diabetes or normoglycemia was based on American Diabetes Association (ADA) criteria. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. After obtaining informed consent, fasting blood samples (8 mL) were collected following a 10-hour overnight fast. Six millilitres of blood were used for the estimation of fasting glucose, lipid profile and serum 25(OH)D and 2 mL were used for HbA1C estimation. Two hours after a meal, a second 2 mL blood sample was drawn for postprandial glucose analysis. Plasma was separated by centrifugation at 3000 rpm for 5 minutes and stored at 2–8°C until testing.

Biochemical analyses were performed at BIRDEM's biochemistry laboratories. Plasma glucose was measured using the glucose hexokinase method and HbA1C by high-performance liquid chromatography (HPLC). Lipid profile parameters were measured enzymatically and LDL was calculated using the Friedewald equation. Serum 25(OH)D was also measured by HPLC. Ethical approval was obtained from the Ethical Review Committee of the Diabetic Association of Bangladesh. Data were analyzed using SPSS version 21, with statistical significance set at $p \leq 0.05$.

RESULTS

Table 1 shows the baseline characteristics of study subjects. The mean age was 51.06 ± 9.78 in diabetics and 48.50 ± 11.21 in non-diabetics. No significant difference in age distribution. Diabetic group include 58 males and 72 females. Non diabetic group include 27 males and 43 females. The mean $\pm$ SD of BMI in diabetics was 26.10 ± 4.02 and in nondiabetics was 24.63 ± 3.1 . BMI was significantly higher in diabetics than non-diabetics ($p=0.009$).

Table 2 presents the comparison of vitamin D between two groups of the study subjects. The mean $\pm$ SD of plasma vitamin D concentration of diabetic group was 22.37 ± 8.34 ng/ml and the mean $\pm$ SD of plasma vitamin D concentration of non-diabetics were 28.92 ± 10.46 ng/ml. Plasma vitamin D concentration was found to be significantly low in type 2 diabetics compared to non-diabetics ($p < 0.001$).

Table 3 presents the comparison of biochemical parameters of the study subjects. In type 2 diabetics Fasting plasma glucose, 2 hours postprandial blood glucose and HbA1c were significantly high compared to

non-diabetic subjects ($p<0.001$). Total cholesterol, LDL-cholesterol and TG were significantly high in type 2 diabetic patients compared to non-diabetic subjects ($p<0.001$). But HDL-cholesterol concentration is high in non-diabetics than diabetics. But the difference is statistically not significant ($p=0.134$).

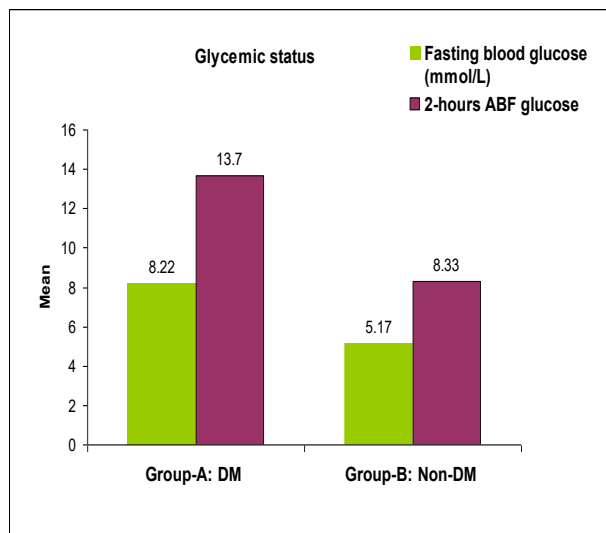


Figure 1: Glycemic status of the participants.

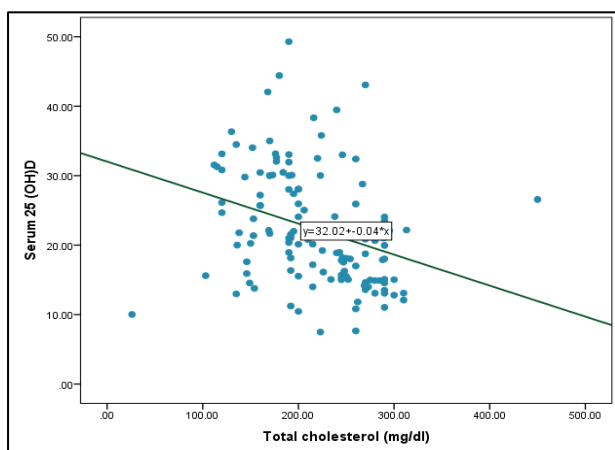


Figure 2: Correlation between serum 25 (OH)D and TC (mg/dl) in DM group.

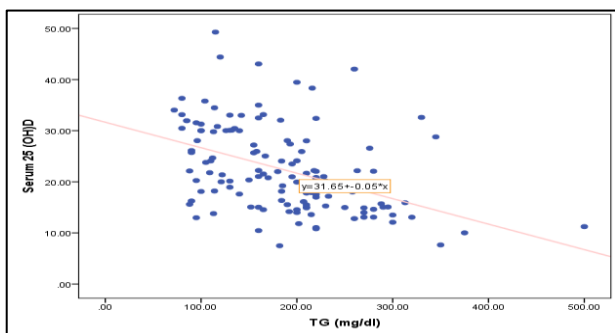


Figure 3: Correlation between serum 25 (OH)D and TG (mg/dl) in DM group.

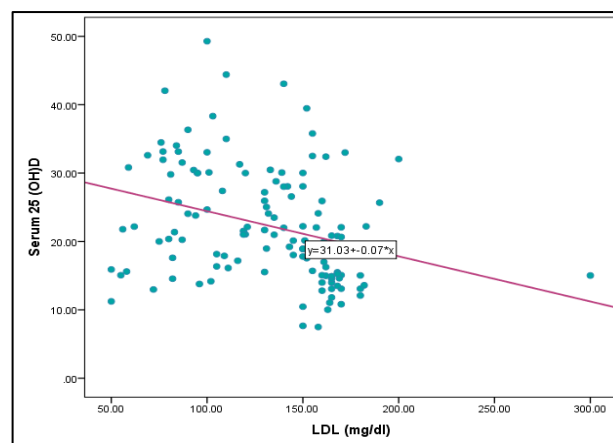


Figure 4: Correlation between serum 25 (OH)D and LDL (mg/dl) in DM group.

Figure 1 illustrates the mean fasting blood glucose (FBG) and 2-hours after breakfast (ABF) glucose levels among two groups: type 2 diabetic patients (Group A) and healthy normoglycemic individuals (Group B). In Group A, the mean FBG was 8.22 mmol/l, while the 2-hour ABF glucose was significantly higher at 13.7 mmol/L. In contrast, Group B showed a mean FBG of 5.17 mmol/L and a 2-hour ABF glucose of 8.33 mmol/L.

Table 4 shows the correlation of vitamin D with lipid profile and glycemic status in the study subjects. In diabetic group vitamin-D showed positive correlation with HDL ($r=+0.269$) and negative correlation with HbA1C ($r=-0.236$), Fasting plasma glucose ($r=-0.303$), 2-hours postprandial blood glucose ($r=-0.184$), Total cholesterol ($r=-0.320$), LDL ($r=-0.320$), TG ($r=-0.438$). Correlation is statistically significant with all the parameters. In non-diabetic group there was no significant correlation between vitamin-D with HbA1c ($r=-0.174$, $p=0.150$), Fasting blood glucose ($r=-0.208$, $p=0.084$) and 2-hours postprandial glucose ($r=-0.062$, $p=0.608$). Also no statistically significant correlation was found between vitamin D with Total cholesterol ($r=-0.199$, $p=0.099$), LDL ($r=-0.168$, $p=0.165$), TG ($r=-0.173$, $p=0.153$) and HDL-C ($r=+0.205$, $p=0.089$).

Figure 2 illustrates the correlation between serum 25-hydroxyvitamin D (25(OH)D) levels and total cholesterol (TC) levels in individuals with type 2 diabetes mellitus (DM group). Each point represents an individual participant's serum 25(OH)D and TC values. The regression line demonstrates a negative linear relationship, as indicated by the equation $y = 32.02 - 0.04x$, suggesting that higher total cholesterol levels are associated with lower serum 25 (OH)D concentrations.

Figure 3 demonstrates the relationship between serum 25-hydroxyvitamin D (25(OH)D) levels and triglyceride (TG) levels in individuals with type 2 diabetes mellitus (DM group). Each dot represents a participant's individual values for serum 25(OH)D and TG.

Figure 4 illustrates the correlation between serum 25-hydroxyvitamin D (25(OH)D) levels and low-density lipoprotein (LDL) cholesterol (mg/dL) in individuals with

type 2 diabetes mellitus (DM group), as depicted by a scatter plot where each point represents a participant's paired measurements.

Table 1: Baseline characteristics of study subjects (n=200).

Baseline characteristics	Group-A: DM (n=130)	Group-B: Non-DM (n=70)	P value
Age (in years)	51.06±9.78	48.50±11.21	0.095
Gender			
Male	58 (44.6%)	27 (38.6%)	
Female	72 (55.4%)	43 (61.4%)	
Body mass index			
BMI (kg/m ²)	26.10±4.02	24.63±3.1	0.009

Unpaired Student t-test was used to compare the groups. p<0.05 was considered as significant.

Table 2: Comparison of vitamin D between two groups of the study subjects (n=200).

Vitamin D	Group-A: DM (n=130)	Group-B: Non-DM (n=70)	P value
Plasma 25 (OH)D (ng/ml)	22.37±8.34	28.92±10.46	<0.001

Unpaired Student's t-test was used to compare between groups. p<0.05 was considered as significant.

Table 3: Comparison of biochemical parameters of the study subjects (n=200).

Biochemical parameters	Group-A: DM (n=130)	Group-B: Non-DM (n=70)	P value
Glycemic status			
HbA _{1c} %	8.62±5.56	5.71±0.43	<0.001
Fasting plasma glucose (mmol/l)	8.22±1.95	5.17±0.62	<0.001
2-hours postprandial blood glucose (mmol/l)	13.70±2.74	8.33±1.99	<0.001
Lipid profile			
Total cholesterol (mg/dl)	216.34±59.74	167.91±40.66	<0.001*
LDL (mg/dl)	131.22±39.96	100.40±29.40	<0.001*
TG (mg/dl)	186.34±73.31	128.76±65.54	<0.001*
HDL (mg/dl)	41.43±8.49	43.34±8.72	0.134

Unpaired Student t-test was used to compare between groups. *p<0.05 was considered as significant.

Table 4: Correlation of Vitamin D with lipid profile and glycemic status in the study subjects (n=200).

Parameters	Pearson's correlation			
	Group-A: DM (n=130)		Group-B: Non-DM (n= 70)	
	r	p	r	p
HbA _{1c} %	-0.236	0.007	-0.174	0.150
Fasting blood glucose (mmol/L)	-0.303	<0.001	-0.208	0.084
2-hours post prandial glucoseol	-0.184	0.036	-0.062	0.608
Total cholesterol (mg/dl)	-0.320	<0.001	-0.199	0.099
LDL (mg/dl)	-0.317	<0.001	-0.168	0.165
TG (mg/dl)	-0.438	<0.001	-0.173	0.153
HDL (mg/dl)	+0.269	0.002	+0.205	0.089

Pearson's correlation coefficient (r) test to compare relationship between Vitamin D with glycemic status and lipid profile. The level of significance was calculated and p value <0.05 was accepted as level of significance.

DISCUSSION

This study investigated the association between vitamin D status and glycemic as well as lipid profiles in individuals with and without type 2 diabetes mellitus (T2DM). The results demonstrated that diabetic patients had significantly lower serum 25-hydroxyvitamin D

(25(OH)D) levels compared to non-diabetic controls and these lower levels were associated with poorer glycemic control and adverse lipid profiles. The mean serum 25(OH)D concentration in the diabetic group was markedly lower (22.37±8.34 ng/ml) than in non-diabetic individuals (28.92±10.46 ng/ml, p<0.001), suggesting a higher prevalence of vitamin D deficiency among T2DM

patients. This finding aligns with earlier studies by Scragg et al and Subramanian et al, who reported a strong link between vitamin D deficiency and diabetes, particularly in certain ethnic and geographic populations.^{12,13} The underlying mechanisms may involve vitamin D's regulatory effects on pancreatic β -cell function, insulin sensitivity and chronic inflammation, as discussed by Nemerovski et al and Wang et al.^{14,15}

The study further found significant inverse correlations between serum vitamin D levels and key glycemic parameters among diabetics HbA1c, fasting glucose and 2-hour postprandial glucose. These results are consistent with findings by Bhosle et al and Ahdal et al, who demonstrated improvements in glycemic indices with vitamin D supplementation in T2DM patients.^{16,17} Hu et al, also confirmed this association in their meta-analysis of interventional studies, supporting the potential role of vitamin D in glycemic regulation.¹⁸ Additionally, a notable association was observed between vitamin D status and lipid parameters. In the diabetic group, serum 25(OH)D showed significant negative correlations with total cholesterol, LDL and triglycerides and a positive correlation with HDL. These findings are in agreement with Kandeel et al and Atalay et al, who reported that low vitamin D levels may contribute to atherogenic dyslipidemia, a frequent complication in T2DM.^{19,20} The inverse relationship between vitamin D and triglycerides was further illustrated by scatter plot analysis, showing a strong negative correlation.

Although BMI was significantly higher in diabetics than in non-diabetics ($p=0.009$), the relationship between BMI and vitamin D was not directly explored in this study. Nevertheless, it is well-established that increased adiposity can reduce the bioavailability of vitamin D due to its sequestration in adipose tissue, a hypothesis supported by Dutta et al and Shu et al.^{21,22} This mechanism may further exacerbate vitamin D deficiency in individuals with T2DM who often exhibit higher BMI. Interestingly, the absence of significant associations between vitamin D and metabolic markers in the non-diabetic group may suggest that vitamin D's influence becomes more critical in the dysregulated metabolic milieu characteristic of diabetes. This hypothesis is echoed in recent studies by Mahmood et al and Syed Khaja et al, which emphasized vitamin D's stronger associations with glucose metabolism and inflammatory pathways in diabetic individuals.^{23,24}

Our findings reinforce the emerging evidence that vitamin D deficiency is prevalent in T2DM and may be intricately linked to poor glycemic control and dyslipidemia. Given the cross-sectional nature of this study, further longitudinal and interventional research is warranted to explore causality and the therapeutic potential of vitamin D in metabolic diseases.

This study had several limitations. The sample size was relatively small and limited to a specific age group, which may affect the generalizability of the results. All

participants were selected from a single tertiary care hospital in Bangladesh, potentially introducing selection bias. Additionally, the cross-sectional design limits the ability to infer causality or observe long-term effects, making the findings less representative of the broader population.

CONCLUSION

This study demonstrated that vitamin D deficiency is significantly associated with poor glycemic control and adverse lipid profiles in individuals with type 2 diabetes mellitus. These findings suggest that hypovitaminosis D may play a role in the metabolic disturbances commonly observed in diabetic patients. Routine screening and correction of vitamin D deficiency could serve as a valuable strategy in the management and complication prevention of type 2 diabetes. Further large-scale, longitudinal and multi-center studies are warranted to validate these associations and inform clinical practice.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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