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Correlation of 25-Hydroxyvitamin D with Lipid Profiles (TG, TC, LDL, HDL) in Type 2 Diabetic Individuals

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Abstract

Background: Vitamin D deficiency and dyslipidemia are both common in individuals with type 2 diabetes and may contribute to increased cardiovascular risk. This study aims to assess the correlation between serum 25-hydroxyvitamin D levels and lipid profile parameters in patients with type 2 diabetes mellitus. ***Aim of the study:*** The aim of the study was to evaluate the correlation between 25-Hydroxyvitamin D levels and lipid profiles (TG, TC, LDL, HDL) in individuals with Type 2 diabetes. ***Methods:*** This cross-sectional study was conducted at the Department of Clinical Biochemistry and the Department of Biochemistry and Cell Biology, BIRDEM General Hospital, Dhaka, Bangladesh, from July 2014 to June 2015, including 200 participants (130 with type 2 diabetes, 70 healthy controls). After informed consent, demographic data and blood samples were collected for fasting plasma glucose, lipid profile, 25-hydroxyvitamin D, HbA1C, and postprandial glucose analysis. Biochemical tests were performed using standard methods, and data were analyzed with SPSS v21, with statistical significance set at $p \leq 0.05$. ***Results:*** Type 2 diabetics had significantly lower vitamin D levels and higher BMI compared to non-diabetics. Hypovitaminosis-D was more common in diabetics (44.6% vs. 22.9%, $p = 0.002$). Diabetics also had higher total cholesterol, LDL, and triglycerides (all $p < 0.001$). In diabetics, vitamin D levels were inversely correlated with cholesterol, LDL, and triglycerides, and positively correlated with HDL. ***Conclusion:*** Vitamin D deficiency is significantly associated with dyslipidemia in type 2 diabetic patients, showing strong negative correlations with LDL and triglycerides and a positive correlation with HDL.

Keywords: Vitamin D, Lipid profile, Type 2 diabetes.

INTRODUCTION

Diabetes mellitus ranks among the most widespread metabolic disorders globally [1]. Type 2 diabetes represents over 90% of all confirmed diabetes diagnoses [2]. It is frequently accompanied by a constellation of lipid and lipoprotein abnormalities, including elevated triglycerides, decreased high-density lipoprotein (HDL) cholesterol, and an increased presence of small, dense low-density lipoprotein (LDL) particles. These lipid alterations are often evident even when LDL cholesterol levels are within the normal range and are commonly associated with insulin resistance, a central feature of type 2 diabetes [3]. Notably, individuals in the pre-diabetic phase may already exhibit an atherogenic lipid profile characterized by higher levels of total cholesterol, LDL cholesterol, and triglycerides, and reduced HDL cholesterol compared to those who do not go on to develop diabetes [3].

Vitamin D, a fat-soluble vitamin, is widely recognized for its essential role in bone metabolism and calcium homeostasis. However, emerging evidence from recent decades suggests that vitamin D deficiency may contribute to a broad spectrum of non-skeletal conditions [4], such as hypertension [5], cardiovascular disorders [6,7], autoimmune diseases, type 1 and type 2 diabetes [7], osteoporosis, and certain malignancies [8].

Numerous cross-sectional and interventional studies have indicated a link between low vitamin D levels and impaired glucose regulation, as well as the development of diabetes mellitus [9,10].

Vitamin D is synthesized in the skin through sunlight exposure or obtained from dietary sources. It is first metabolized in the liver to form 25-hydroxyvitamin D [25(OH)D], which is the primary circulating form used clinically to assess vitamin D status [8]. Although 25(OH)D is not biologically active, it undergoes further hydroxylation in the kidneys by the enzyme 25-hydroxyvitamin D-1α-hydroxylase to become the active hormone 1,25-dihydroxyvitamin D [1,25(OH)2D] [11]. The vitamin D receptor (VDR), along with the enzyme responsible for this activation, is expressed in multiple tissues [11].

A serum 25(OH)D concentration less than 20 ng/mL is considered *vitamin D deficient* [4,8]. It is estimated that around one billion individuals worldwide are affected by this deficiency [12]. Contributing factors include inadequate sunlight exposure, consistent use of sunscreen, aging, wearing of concealing clothing, insufficient dietary intake of ergocalciferol, and disorders that impair intestinal absorption [13].

Cardiovascular disease (CVD) remains the leading cause of mortality in individuals with type 2 diabetes. Vitamin D has been implicated in multiple cardiovascular processes, including modulation of vascular tone, endothelial function, coronary artery calcification, and systemic vascular resistance. It also appears to influence blood pressure regulation and lipid metabolism, which may partially explain its association with CVD risk [14].

This study aims to assess serum 25(OH)D levels and lipid profile parameters in individuals with type 2 diabetes mellitus receiving care at BIRDEM General Hospital.

Objective

- The aim of the study was to evaluate the correlation between 25-Hydroxyvitamin D levels and lipid profiles (TG, TC, LDL, HDL) in individuals with Type 2 diabetes.

METHODOLOGY & MATERIALS

This cross-sectional study was conducted at the Department of Clinical Biochemistry and the Department of Biochemistry and Cell Biology, BIRDEM General Hospital, Dhaka, Bangladesh, from July 2014 to June 2015. A total of 200 participants aged 30 to 70 years were included, comprising 130 patients with type 2 diabetes mellitus and 70 healthy non-diabetic controls. Participants were selected from the outpatient department of BIRDEM General Hospital based on specific inclusion and exclusion criteria to investigate the relationship between serum vitamin D levels and lipid profiles in diabetic and non-diabetic individuals.

Inclusion Criteria:

- Adults aged 30 to 70 years
- Both male and female participants
- Type 2 diabetic patients attending the outpatient department of BIRDEM General Hospital
- Healthy, non-diabetic individuals as controls

Exclusion Criteria:

- Individuals taking lipid-lowering medications
- Individuals taking vitamin D or calcium supplements
- Patients with advanced chronic liver or renal disease
- Patients with connective tissue disorders such as gout or rheumatoid arthritis
- Pregnant or lactating women

After obtaining informed consent, demographic and clinical data were collected using a structured questionnaire. Diagnosis of type 2 diabetes mellitus (T2DM) and normoglycemia was confirmed based on American Diabetes Association (ADA) criteria from medical records, and body mass index (BMI) was calculated using the standard formula. Following a 10-hour overnight fast, 8 mL of venous blood was collected using aseptic techniques, of which 6 mL was transferred to a plain tube for analysis of fasting plasma glucose, lipid profile, and 25-hydroxyvitamin D [25(OH)D]; 2 mL was preserved in an EDTA tube for HbA1C estimation. A second 2 mL sample was drawn 2 hours post-meal to assess postprandial plasma glucose. Plasma was separated by centrifugation at 3000 rpm for 5 minutes and stored at 2–8°C until analysis.

All biochemical analyses were performed in the laboratories of BIRDEM General Hospital. Fasting and postprandial plasma glucose were measured using the hexokinase method; HbA1C was determined by high-performance liquid chromatography (HPLC); the lipid profile was assessed using enzymatic colorimetric methods, with low-density lipoprotein cholesterol (LDL-C) calculated via the Friedewald equation; and serum 25(OH)D was measured by HPLC. The study protocol was approved by the Ethical Review Committee of the Diabetic Association of Bangladesh.

Data were analyzed using SPSS version 21, with continuous variables expressed as mean ± standard deviation (SD). Comparisons between groups were performed using Student's t-test and Chi-square test. Pearson's correlation was used to assess relationships between serum 25(OH)D and lipid parameters. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

Table 1: Baseline Characteristics of the Study Population (n=200)

Baseline Characteristics		Group-A: DM (n=130)	Group-B: Non-DM (n=70)	P-value
Age (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/m²)	26.10 ± 4.02	24.63 ± 3.1	0.009
Vitamin D	Plasma 25(OH)D (ng/ml)	22.37 ± 8.34	28.92 ± 10.46	<0.001

The mean age of the diabetic group was 51.06 ± 9.78 years, while that of the non-diabetic group was 48.50 ± 11.21 years, with no statistically significant difference between them. The diabetic group included 58 males and 72 females, whereas the non-diabetic group comprised 27 males and 43 females. The mean ± SD of BMI was significantly higher in diabetics (26.10 ± 4.02 kg/m²) compared to non-diabetics (24.63 ± 3.10 kg/m²; $p = 0.009$). The mean plasma 25(OH) vitamin D concentration was significantly lower in the diabetic group (22.37 ± 8.34 ng/ml) than in the non-diabetic group (28.92 ± 10.46 ng/ml; $p < 0.001$).

Table 2: Distribution of the Study Population by Status of Hypovitaminosis-D (n = 200)

Hypovitaminosis-D (<20 ng/ml)	Group-A: DM (n=130)	Group-B: Non-DM (n=70)	P-value
Present	58 (44.6%)	16 (22.9%)	0.002
Absent	72 (55.4%)	54 (77.1%)	
Total	130 (100.0%)	70 (100.0%)	

The prevalence of hypovitaminosis-D (defined as serum 25(OH)D < 20 ng/ml) was significantly higher in the diabetic group (44.6%) compared to the non-diabetic group (22.9%). This difference was statistically significant, indicating a strong association between hypovitaminosis-D and type 2 diabetes ($p = 0.002$).

Table 3: Comparison of Lipid Profile Parameters of the Study Subjects (n = 200)

Lipid Profile Parameters	Group-A: DM (n=130)	Group-B: Non-DM (n=70)	P-value
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
Triglycerides (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

In type 2 diabetic individuals, total cholesterol, LDL-cholesterol, and triglyceride (TG) levels were significantly higher compared to non-diabetic individuals ($p < 0.001$). Although HDL-cholesterol levels were higher in the non-diabetic group, the difference was not statistically significant ($p = 0.134$).

Table 4: Correlation of Vitamin D with Lipid Profile in the Study Population (n = 200)

Parameters	Group-A: DM (n = 130)		Group-B: Non-DM (n = 70)	
	r	p	r	p
Total cholesterol (mg/dl)	-0.32	<0.001	-0.199	0.099
LDL (mg/dl)	-0.317	<0.001	-0.168	0.165
Triglycerides (TG) (mg/dl)	-0.438	<0.001	-0.173	0.153
HDL (mg/dl)	+0.269	0.002	+0.205	0.089

In the diabetic group, serum vitamin D levels showed a significant negative correlation with total cholesterol (r = –0.320, $p < 0.001$), LDL (r = –0.317, $p < 0.001$), and triglycerides (TG) (r = –0.438, $p < 0.001$), and a significant positive correlation with HDL (r = +0.269, $p = 0.002$). In contrast, the non-diabetic group showed no statistically significant correlations between vitamin D and any of the lipid profile parameters.

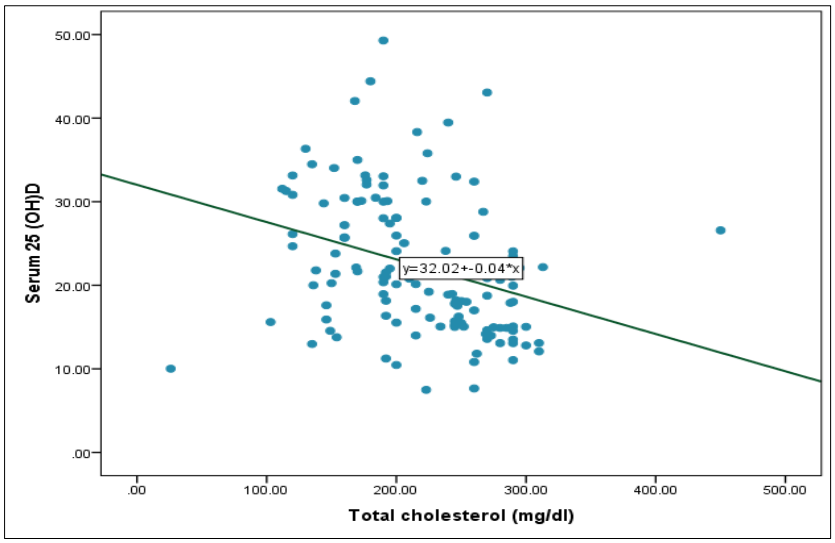

Figure 1: Correlation between Serum 25(OH)D and Total Cholesterol (TC) in the Diabetic Group

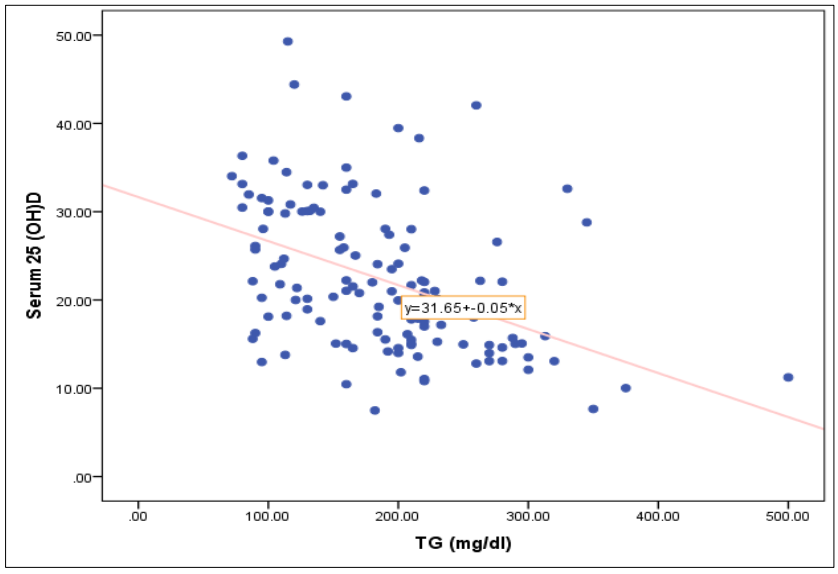

Figure 2: Correlation between Serum 25(OH)D and Triglycerides (TG) in the Diabetic Group

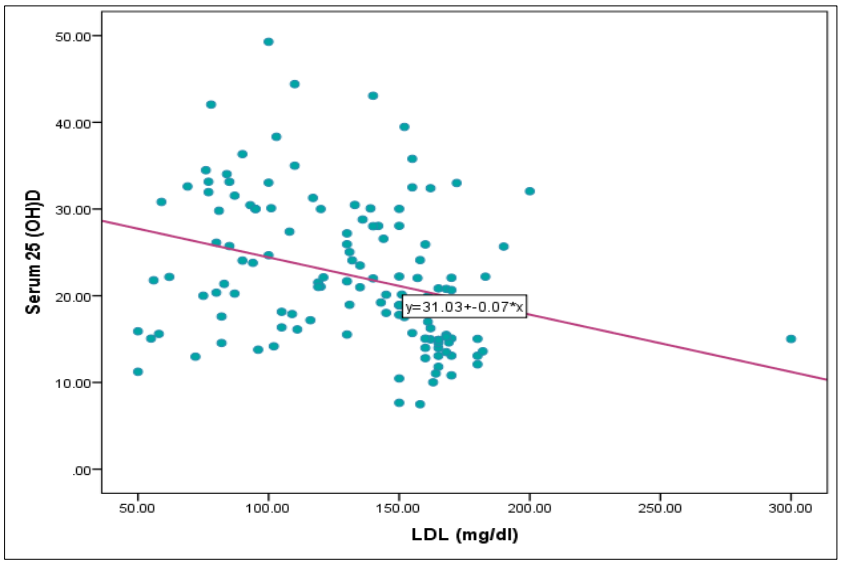

Figure 3: Correlation between Serum 25(OH)D and LDL (mg/dl) in the Diabetic Group

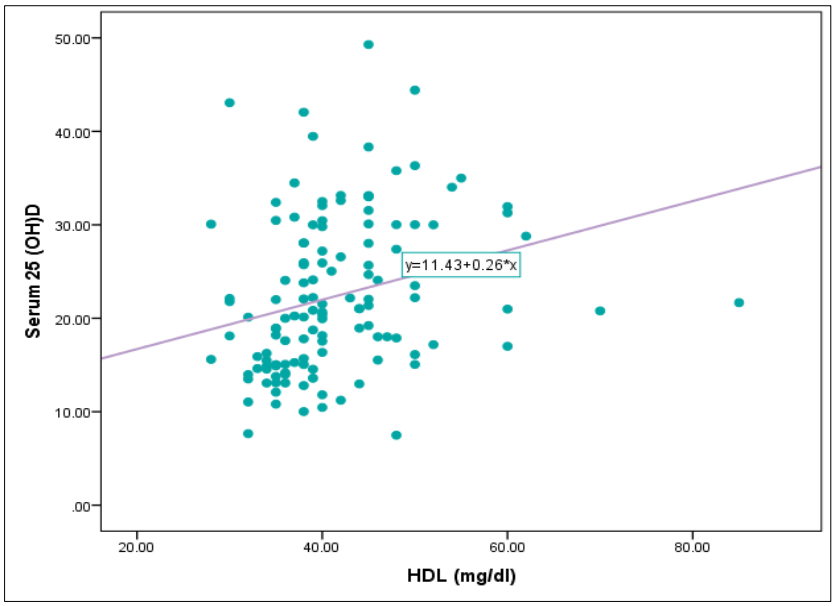

Figure 4: Correlation between Serum 25(OH)D and HDL (mg/dl) in the Diabetic Group

DISCUSSION

The purpose of this cross-sectional study was to evaluate lipid profile parameters and vitamin D levels in people with type 2 diabetes mellitus. Of the 200 participants in the trial, 70 were healthy controls without diabetes and 130 had type 2 diabetes. Every subject had their lipid profiles and plasma 25-hydroxyvitamin D [25(OH)D]] evaluated.

The mean plasma 25(OH)D concentration was found to be significantly lower among diabetic patients compared to non-diabetic controls ($p < 0.001$), consistent with observations made by Chiu *et al.,* [15].

A greater proportion of individuals in the diabetic group exhibited hypovitaminosis D (25(OH)D < 20 ng/ml), with a prevalence of 44.6%, compared to 22.9% in the non-diabetic group. This finding supports earlier study by Mattila *et al.,* [9].

The difference in mean BMI between the diabetic and non-diabetic groups was statistically significant ($p = 0.009$). Although an inverse correlation between 25(OH)D and BMI ($r = -0.2517$) was previously reported by Chiu *et al.,* [15], such an association was not statistically evident in the present study.

Dyslipidemia, commonly seen in type 2 diabetes and often worsened by poor glycemic control, is characterized by elevated LDL cholesterol and oxidative alterations in lipoproteins, as noted by Bos *et al.,* [16]. In our analysis, patients with diabetes showed significantly higher levels of total cholesterol (TC), triglycerides (TG), and low-density lipoprotein cholesterol (LDL-C), along with reduced high-density lipoprotein cholesterol (HDL-C), compared to non-diabetic individuals. The differences were statistically significant for TC, TG, and LDL-C, but not for HDL-C.

Findings from a similar study by Elnasri *et al.,* [17] in Sudan also reported significantly higher cholesterol, TG, and LDL-C levels and reduced HDL-C in vitamin D-deficient diabetic patients compared to those with sufficient vitamin D.

A notable inverse correlation between serum 25(OH)D and TG levels was detected in diabetic patients ($r = -0.438$, $p < 0.001$), aligning with results from the NHANES III study by Ford *et al.,* [18].

In addition, a significant positive relationship was found between vitamin D levels and HDL-C.

Our results also showed a significant inverse relationship between 25(OH)D and both TG and TC concentrations. This trend is comparable to that reported by Saedisomeolia *et al.,* [19], who found inverse (though non-significant) correlations with TG and TC and a positive link with HDL-C.

Moreover, a negative correlation between 25(OH)D and LDL-C was also observed, in agreement with findings by Saedisomeolia *et al.,* [19] and Chiu *et al.,* [15].

Among healthy participants, our data revealed a non-significant negative association between vitamin D and TG levels ($r = -0.173$, $p = 0.153$), which mirrors the observations of Rejnmark *et al.,* [20]. However, Chiu *et al.,* [15] reported no significant association between 25(OH)D and TG in healthy individuals.

Limitations of the study

This study had some limitations:

- A small number of study subjects were included.
- The study was restricted to a limited age group.

- The study was conducted using samples from a single tertiary-level hospital in Bangladesh.
- As a cross-sectional study without follow-up, the data presented are less likely to represent the actual trends in the general population.

CONCLUSION

This study demonstrates that type 2 diabetic patients have significantly lower serum 25-hydroxyvitamin D levels and higher prevalence of hypovitaminosis D (<20 ng/ml) compared to non-diabetic controls. Diabetic subjects exhibited markedly worse lipid profiles, with significantly elevated total cholesterol, LDL-cholesterol, and triglycerides, along with lower (though not statistically significant) HDL-cholesterol levels. Most importantly, we found strong negative correlations between vitamin D levels and total cholesterol (r=-0.320), LDL (r=-0.317), and triglycerides (r=-0.438), along with a positive correlation with HDL (r=+0.269) in the diabetic group - all statistically significant. These findings collectively indicate that vitamin D deficiency is both prevalent in and potentially metabolically consequential for type 2 diabetes patients, being significantly associated with the dyslipidemia characteristic of this condition.

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