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ESTIMATION OF VITAMIN D, HBA1C, AND LIPOPROTEIN LEVELS IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A CASE-CONTROL STUDY"

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ABSTRACT

Introduction: Type-2 Diabetes Mellitus (T2DM) is a global health burden with increasing prevalence and associated complications. Emerging evidence highlights the role of Vitamin D in glycaemic control and lipid metabolism.

Objective: To estimate and analyse the levels of Vitamin D, HbA1C, and lipoproteins in T2DM patients and evaluate their interrelationship.

Methods: A case-control study was conducted from April 2023 to September 2024 involving 100 participants (50 T2DM patients and 50 healthy controls). Vitamin D, HbA1C, lipid profile, and ApoB levels were measured using ELISA, HPLC, nephelometry, and automated analysers. Statistical correlations among the biomarkers were evaluated.

Results: T2DM patients showed significantly lower Vitamin D levels and elevated HbA1C and ApoB levels compared to controls. A negative correlation was observed between Vitamin D and HbA1C, and between Vitamin D and ApoB levels, indicating possible interdependence in metabolic regulation.

Conclusion: Vitamin D deficiency may contribute to poor glycaemic control and dyslipidaemia in T2DM. Monitoring Vitamin D alongside HbA1C and lipid profile can help in comprehensive diabetes management.

Keywords: Type-2 Diabetes Mellitus, Vitamin D, HbA1C, Apo-B, Lipid Profile, Insulin Resistance.

Introduction:

Type 2 Diabetes Mellitus (T2DM) is a chronic, progressive metabolic disorder characterized by insulin resistance and β-cell dysfunction, leading to persistent hyperglycaemia. It accounts for approximately 90% of all diabetes cases globally and is a major public health challenge, particularly

in developing countries like India, where an estimated 77 million adults are affected, a number projected to rise significantly in the coming decades [1,2].

Vitamin D, a fat-soluble secosteroid hormone primarily synthesized in the skin upon exposure to ultraviolet B radiation, plays a central role in calcium-phosphate homeostasis. Recent evidence highlights its extra-skeletal effects, especially in glucose metabolism and immune regulation [3]. Vitamin D receptors (VDRs) are present in pancreatic β-cells, and its active form, calcitriol [1,25(OH)$_2$D], modulates insulin synthesis, secretion, and sensitivity through multiple pathways, including regulation of intracellular calcium, suppression of inflammatory cytokines, and upregulation of insulin receptor expression [4,5].

Haemoglobin A1c (HbA1c) is a key indicator of long-term glycaemic control, reflecting average plasma glucose over 2–3 months. Elevated HbA1c levels are strongly associated with increased risk of both microvascular and macrovascular complications in T2DM [6]. Moreover, poor glycaemic control correlates with dyslipidaemia, a frequent comorbidity in T2DM, characterized by elevated triglycerides, low HDL-C, and increased small dense LDL particles [7]. Apolipoprotein B (ApoB), the main structural protein of atherogenic lipoproteins (LDL, VLDL, and IDL), provides a more accurate estimate of cardiovascular risk compared to LDL-C levels alone, particularly in patients with insulin resistance or diabetes [8]. Studies suggest that vitamin D deficiency is linked to increased insulin resistance, hyperglycaemia, and dysregulated lipid metabolism, yet the direction and strength of these relationships remain inconsistent across populations [9].

The interaction between Vitamin D levels, glycaemic markers such as HbA1c, and lipid parameters including ApoB may offer insights into the underlying pathophysiology of T2DM and its associated complications. Despite emerging evidence, there is limited data from central India addressing this interplay in diabetic populations.

Therefore, this study aims to evaluate serum levels of Vitamin D, HbA1c, and lipoproteins (specifically ApoB and lipid profile components) in patients with T2DM and compare them with non-diabetic controls. Additionally, we aim to assess the correlations between Vitamin D levels and metabolic markers such as BMI, HbA1c, and ApoB.

Aims and Objectives

Aim: To evaluate the levels of Vitamin D, HbA1c, and lipoproteins in patients with Type 2 Diabetes Mellitus (T2DM) and explore their interrelationships.

Objectives:

1. To estimate serum Vitamin D [25(OH)D] levels in patients with T2DM and compare them with non-diabetic controls.
2. To assess glycaemic control by measuring Haemoglobin A1c (HbA1c) levels in T2DM patients.
3. To evaluate lipid profile parameters—including total cholesterol, triglycerides, HDL-C, LDL-C, and VLDL-C—and Apolipoprotein B (ApoB) in T2DM patients.
4. To investigate the correlation between Vitamin D levels and:
   - HbA1c (as a marker of glycaemic control)
   - Lipid profile parameters, especially ApoB (as markers of dyslipidaemia)
   - Body Mass Index (BMI) (as a marker of obesity-related metabolic risk)
5. To compare the biochemical profiles of T2DM patients with age- and sex-matched healthy controls to identify statistically significant differences.

Materials and Methods

This hospital-based case-control study was conducted at LSLAM GMC Raigarh (C.G.) from April 2023 to September 2024, following ethical approval. A total of 100 participants were included—50 T2DM patients (cases) and 50 healthy controls—aged between 30–65 years.

Inclusion Criteria:
Diagnosed T2DM (HbA1c ≥ 6.5%) for cases; non-diabetic healthy individuals for controls.

Exclusion Criteria:
Type 1 DM, gestational diabetes, age outside the range, vitamin D supplementation, chronic illnesses, or immunocompromised status.

Sample Collection and Processing:
5 mL fasting venous blood was collected, with serum separated for biochemical analysis and EDTA samples used for HbA1c.

Parameters Measured:
• **Vitamin D**: ELISA (Monocent Kit)
• **HbA1c**: HPLC (Bio-Rad D-10)
• **ApoB**: Nephelometry (Agappe Mispa-i2)
• **Lipid Profile, RFT, LFT, FBG**: Automated analyzer (Agappe Mispa Clinia)
• **BMI**: Calculated from weight (Kg) and height (m^2)

Statistical Analysis:
Data analyzed using SPSS v25. Pearson's correlation and Chi-square test used for correlation and associations among Vitamin D, HbA1c, ApoB, and BMI. $p < 0.05$ was considered significant.

Results:
A total of 100 subjects were studied, including 50 Type 2 Diabetes Mellitus (T2DM) patients and 50 age- and sex-matched healthy controls. Both groups had an equal male-to-female ratio (25:25).
Demographic and BMI Distribution
The majority of cases (44%) were in the 40–49 years age group, while most controls (60%) were in the 30–39 years group. Among cases, 74% were overweight, while none of the controls were overweight.

Table 1 presents the age and BMI distribution.

Parameter	Cases (n=50)	Controls (n=50)
Age 40–49 yrs	22 (44%)	17 (34%)
Age 30–39 yrs	13 (26%)	30 (60%)
Overweight (BMI > 24.9)	37 (74%)	0 (0%)
Normal BMI	13 (26%)	25 (50%)
Underweight	0 (0%)	25 (50%)

Clinical Symptoms in T2DM Patients
Common symptoms among T2DM cases were polyphagia (74%), polydipsia (44%), and nocturia (38%), compared to significantly lower rates in controls (24%, 20%, and 4% respectively).

Biochemical Parameters
Significant differences were observed between cases and controls in Vitamin D, HbA1c, and ApoB levels ($p < 0.001$). T2DM cases had significantly lower Vitamin D levels and higher HbA1c and ApoB concentrations, reflecting poor glycaemic control and dyslipidaemia.

Table 2. Key Biochemical Parameters in Cases vs Controls

Parameter	Cases (Mean ± SD)	Controls (Mean ± SD)	p-value
Vitamin D (ng/mL)	16.93 ± 2.42	27.56 ± 1.04	< 0.001
HbA1c (%)	8.10 ± 1.20	5.20 ± 0.48	< 0.001
ApoB (mg/dL)	132.5 ± 14.3	98.4 ± 10.7	< 0.001

Correlation Analysis

Vitamin D levels showed a strong negative correlation with BMI (r = -0.957), HbA1c (r = -0.812), and ApoB (r = -0.776), all statistically significant ($p < 0.001$), indicating that lower Vitamin D levels are associated with increased metabolic risk factors.

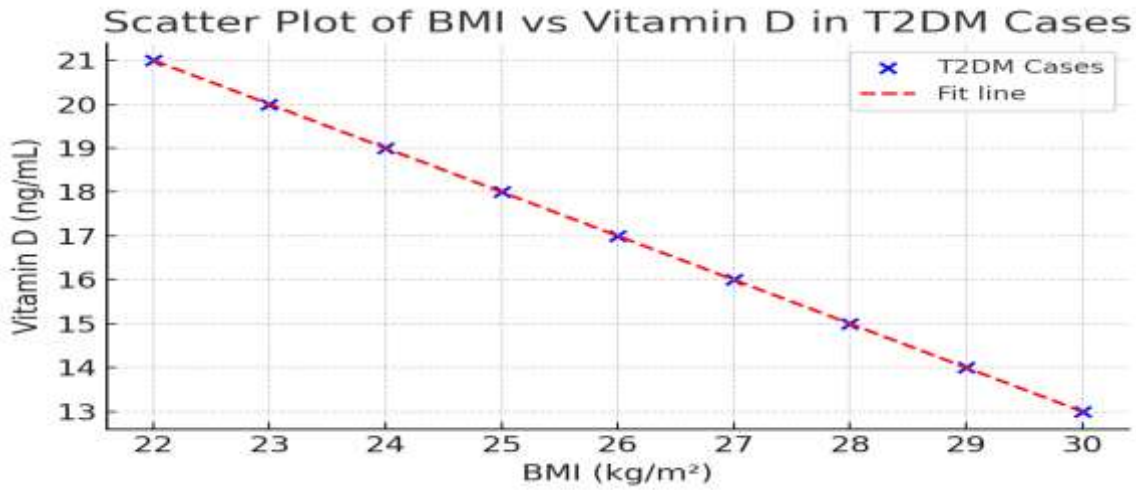
Table 3. Correlation Between Vitamin D and Other Parameters

Parameter	Correlation (r)	p-value
Vitamin D vs BMI	-0.957	< 0.001
Vitamin D vs HbA1c	-0.812	< 0.001
Vitamin D vs ApoB	-0.776	< 0.001

Graphical Representation

A scatter plot demonstrates a steep inverse relationship between BMI and Vitamin D levels in T2DM cases, reinforcing the strong negative correlation identified.

Figure 1. Scatter Plot of BMI vs Vitamin D in T2DM Cases



Discussion

This study evaluated and compared Vitamin D, HbA1c, and lipoprotein (ApoB) levels in patients with Type 2 Diabetes Mellitus (T2DM) and healthy controls, with an additional focus on their interrelationships. The findings demonstrated significantly lower Vitamin D levels and significantly higher HbA1c and ApoB levels in T2DM patients compared to controls. Furthermore, Vitamin D levels exhibited strong negative correlations with BMI, HbA1c, and ApoB, indicating its potential role in glucose and lipid metabolism.

Vitamin D deficiency was more prevalent among T2DM patients, aligning with earlier studies that link hypovitaminosis D to insulin resistance and impaired β-cell function [4,10]. Vitamin D receptors (VDRs) present in pancreatic β-cells are known to regulate insulin synthesis and secretion through modulation of intracellular calcium and inflammatory cytokines [11,12]. Reduced Vitamin D levels may therefore impair glucose homeostasis and contribute to worsening glycaemic control.

HbA1c, a reliable marker for long-term glycaemic status, was significantly elevated in diabetic cases in our study. This is consistent with its diagnostic role in diabetes and its association with chronic complications [13]. The inverse relationship between Vitamin D and HbA1c observed in this study supports the hypothesis that Vitamin D deficiency may exacerbate poor glycaemic control [5]. Some interventional trials have reported improved insulin sensitivity and glycaemic control following Vitamin D supplementation, although results remain mixed and population-specific [14].

Dyslipidaemia, particularly elevated ApoB levels, was also significantly associated with T2DM patients. ApoB is a major structural component of atherogenic lipoproteins and is more reflective of

cardiovascular risk than LDL-C alone [15]. The negative correlation between Vitamin D and ApoB in this study aligns with reports suggesting that Vitamin D influences lipid metabolism through modulation of hepatic lipogenesis, VLDL synthesis, and LDL receptor activity [16].

BMI was significantly higher in T2DM patients and strongly negatively correlated with Vitamin D levels. Obesity is a well-established risk factor for insulin resistance and has been associated with lower bioavailability of Vitamin D due to its sequestration in adipose tissue [17]. This triad of high BMI, low Vitamin D, and metabolic derangements underscores the interconnectedness of endocrine, nutritional, and cardiovascular pathways in T2DM pathophysiology.

Overall, the data highlight the potential utility of assessing Vitamin D status as part of the metabolic profiling in T2DM patients. Early detection and correction of Vitamin D deficiency could serve as a supportive strategy in improving glycaemic control and mitigating lipid-related cardiovascular risks.

Conclusion

This study demonstrates that patients with Type 2 Diabetes Mellitus have significantly lower serum Vitamin D levels and higher HbA1c and ApoB levels compared to healthy controls. The strong inverse correlations between Vitamin D and BMI, HbA1c, and ApoB suggest that Vitamin D deficiency may contribute to poor glycaemic control, dyslipidaemia, and increased cardiovascular risk in T2DM.

These findings highlight the importance of routine assessment of Vitamin D status in diabetic patients as part of comprehensive metabolic monitoring. Early identification and correction of Vitamin D deficiency could serve as a potential adjunctive strategy in managing T2DM and reducing its associated complications.

Further large-scale, longitudinal, and interventional studies are warranted to establish the causal role of Vitamin D and the therapeutic benefits of its supplementation in the prevention and control of Type 2 Diabetes Mellitus.

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