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VITAMIN D DEFICIENCY AND INSULIN RESISTANCE: A CROSS-SECTIONAL STUDY IN NEWLY DIAGNOSED TYPE 2 DIABETES PATIENTS

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Abstract

Background: *Vitamin D deficiency has been proposed as a contributing factor to insulin resistance and the development of type 2 diabetes mellitus (T2DM). However, its role in newly diagnosed patients remains unclear.* ***Objectives:*** *To assess the association between serum vitamin D levels and insulin resistance in patients newly diagnosed with type 2 diabetes.* ***Methods:*** *This cross-sectional, observational study was conducted at Rawalpindi Medical University, Rawalpindi from 10th June 2024 to 20th December 2024. A total of 175 patients newly diagnosed with T2DM were enrolled in the study. Detailed demographic and clinical data were recorded for each participant, including age, gender, duration of diabetes, body mass index (BMI), waist circumference, and relevant lifestyle information such as physical activity and sun exposure. Anthropometric measurements were taken using standardized protocols.* ***Results:*** *The mean vitamin D level in the cohort was 21.6 ± 7.4 ng/mL, with 88.7%, 90.4%, and 90.5% of patients in the deficient, insufficient, and sufficient groups respectively classified as insulin resistant. Mean HOMA-IR values were 4.96 ± 2.09 (deficient), 4.86 ± 1.98 (insufficient), and 4.81 ± 1.85 (sufficient). No statistically significant difference in insulin resistance was found between the groups ($p > 0.05$). Pearson correlation between vitamin D and HOMA-IR was weak and non-significant ($r = -0.02$, $p = 0.79$).* ***Conclusion:*** *It is concluded that vitamin D deficiency is highly prevalent in newly diagnosed type 2 diabetes patients; however, no significant association was observed between vitamin D levels and insulin resistance.*

INTRODUCTION

Type 2 diabetes mellitus (T2DM) develops as a metabolic condition which creates persistent high blood sugar through both insulin resistance and insulin deficiency imbalance [1]. Research shows that diabetes emerges as a significant worldwide health issue because demographic changes, population density growth and inactive behavior and rising weight problems contribute to rising prevalence rates [2]. Worldwide a total of 537 million adults endured diabetes in 2021 and predictions indicate a growing figure to reach 643 million adults by 2030 based on International Diabetes Federation (IDF) reports [3]. The successful treatment of diabetes depends on prompt identification of preventable risk factors in

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new T2DM patients to stop complications from occurring. Research now indicates that vitamin D deficiency plays a role in insulin resistance for new T2DM patients. The hormone function of vitamin D has changed scientific understanding since this nutrient previously served only to maintain bone health and regulate calcium [3]. Vitamin D in its active state [1,25(OH)$_2$D] binds to vitamin D receptors which exist in pancreatic beta cells and adipocytes and skeletal muscle to manage insulin secretion and function [4].

Several observational research reports how the incidence of T2DM is more likely to increase when serum 25-hydroxyvitamin D [25(OH)D] levels decrease [5]. Several mechanisms enable Vitamin D to improve insulin sensitivity: it boosts expression of insulin receptors and allows calcium to enter cells for proper insulin communication and reduces systemic inflammatory elements that cause insulin resistance [6]. The benefits of vitamin D for beta-cell function include protecting these cells from cytokine-induced death and increasing their capability to make insulin [7]. Vitamin D deficiency occurs frequently among patients with T2DM at levels that surpass findings from the normal population according to research findings [8]. Vitamin D deficiency commonly occurs in new T2DM patients because obesity along with outdoor activity limits and dietary deficiencies combine with the high ability of fat tissue to absorb vitamin D [9]. Certain geographic areas along with traditional cultural clothing and dark skin tone increase the risk of vitamin D synthesis deficiency in these regions [10].

The key diagnostic sign of early stage T2DM is insulin resistance which means peripheral tissues fail to properly respond to insulin primarily in muscle liver and adipose tissue [11]. The reduced ability to remove glucose together with elevated gluconeogenesis in the liver intensifies hyperglycemia. The relationship between vitamin D deficiency and this pathophysiological process receives credible support from both cross-sectional and longitudinal studies and interventional trials even though research findings sometimes produce inconsistent results [12]. Randomized controlled trials suggest that vitamin D supplementation boosts insulin sensitivity and cuts back fasting plasma glucose among people who are deficient but other studies found no meaningful benefits [13]. The relationship between vitamin D levels and insulin resistance in newly diagnosed T2DM patients needs full clarification because of multiple important reasons. Pharmaceutical along with lifestyle interventions during the early stage of diabetes provide the highest therapeutic advantage before the disease progresses further [14].

Objective

To assess the association between serum vitamin D levels and insulin resistance in patients newly diagnosed with type 2 diabetes.

Methodology

This cross-sectional, observational study was conducted at Rawalpindi medical University, Rawalpindi during 10th June 2024 to 20th December 2024. A total of 175 patients newly diagnosed with T2DM were enrolled in the study.

Inclusion criteria

- Fasting plasma glucose ≥126 mg/dL (7.0 mmol/L),
- 2-hour plasma glucose ≥200 mg/dL (11.1 mmol/L) during an oral glucose tolerance test,
- Glycated hemoglobin (HbA1c) ≥6.5%,
- Random plasma glucose ≥200 mg/dL (11.1 mmol/L) in a patient with classic symptoms of hyperglycemia.
- Patients aged 30–65 years.
- Newly diagnosed with T2DM (diagnosis within the last 3 months).

Exclusion Criteria

- History of chronic kidney disease, liver disease, or parathyroid disorders.
- Use of medications affecting glucose or vitamin D metabolism (e.g., corticosteroids, anticonvulsants).
- Pregnant or lactating women.
- Patients with type 1 diabetes or latent autoimmune diabetes in adults (LADA), as confirmed by antibody testing when indicated.

Data Collection

Detailed demographic and clinical data were recorded for each participant, including age, gender,

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duration of diabetes, body mass index (BMI), waist circumference, and relevant lifestyle information such as physical activity and sun exposure. Anthropometric measurements were taken using standardized protocols. Venous blood samples were drawn in the morning after an overnight fast of 8 to 12 hours. Laboratory parameters measured included fasting plasma glucose (FPG), fasting serum insulin, glycated hemoglobin (HbA1c), lipid profile, and serum 25-hydroxyvitamin D [25(OH)D]. Serum vitamin D levels were measured using the chemiluminescent immunoassay (CLIA) method. Vitamin D status was categorized as deficient (<20 ng/mL), insufficient (20–30 ng/mL), or sufficient (>30 ng/mL). Insulin resistance was assessed using the Homeostasis Model Assessment of Insulin Resistance (HOMA-IR), calculated using the formula: HOMA-IR = (Fasting insulin in μIU/mL × Fasting glucose in mg/dL) / 405. A HOMA-IR value greater than 2.5 was considered indicative of insulin resistance.

Statistical Analysis

Data were analyzed using SPSS v26. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Correlation between serum vitamin D levels and insulin resistance (HOMA-IR values) was assessed using Pearson's correlation coefficient. A p-value less than 0.05 was considered statistically significant for all analyses.

Results

Data were collected from 175 patients, with a mean age of 46.8 ± 10.5 years; 48% were male and 52% female. The mean BMI was 27.9 ± 4.0 kg/m², and the average waist circumference was 95.9 ± 11.0 cm, indicating a predominantly overweight cohort. Biochemical analysis showed a mean fasting glucose of 141.2 ± 24.4 mg/dL and fasting insulin of 14.0 ± 5.1 μIU/mL, resulting in a mean HOMA-IR of 4.89 ± 1.99, suggestive of significant insulin resistance. Vitamin D levels were suboptimal in most patients, with a mean serum level of 21.6 ± 7.4 ng/mL. A large proportion were either vitamin D deficient (40.6%) or insufficient (47.4%), while only 12% had sufficient levels (>30 ng/mL).

Table 1: Demographic and Baseline Characteristics

Characteristic	**Mean ± SD**
Age (years)	46.8 ± 10.5
Male (%)	48.0%
Female (%)	52.0%
BMI (kg/m²)	27.9 ± 4.0
Waist Circumference (cm)	95.9 ± 11.0
Fasting Glucose (mg/dL)	141.2 ± 24.4
Fasting Insulin (μIU/mL)	14.0 ± 5.1
Vitamin D (ng/mL)	21.6 ± 7.4
HOMA-IR	4.89 ± 1.99
Vitamin D Status	
Insufficient	83.0
Deficient	71.0
Sufficient	21.0

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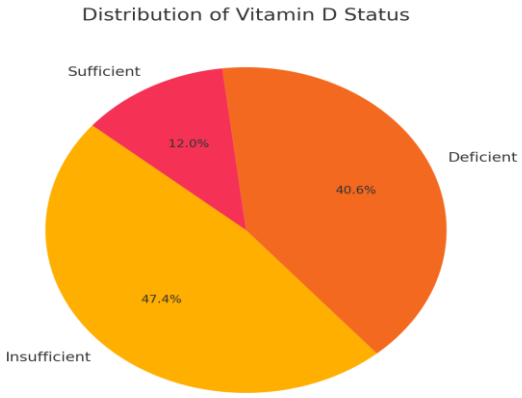

Figure 1: Distribution of Vitamin-D status

Among the 175 patients categorized by vitamin D status, those in the deficient group (n = 71) had the highest mean HOMA-IR value of 4.96 ± 2.09, along with a mean vitamin D level of 14.51 ± 3.89 ng/mL. The insufficient group (n = 83) showed a slightly lower HOMA-IR of 4.86 ± 1.98 and a mean vitamin D concentration of 24.5 ± 2.75 ng/mL. Patients in the sufficient group (n = 21) recorded the lowest mean HOMA-IR of 4.81 ± 1.85 and the highest mean vitamin D level of 34.31 ± 3.06 ng/mL.

Table 2: Group-wise Comparison of Vitamin D Status and HOMA-IR

Vitamin_D_Status	N	Mean_HOMA_IR	Mean_Vitamin_D
Deficient	71.0	4.96±2.09	14.51±3.89
Insufficient	83.0	4.86±1.98	24.5±2.75
Sufficient	21.0	4.81±1.85	34.31±3.06

The distribution of insulin resistance among the three vitamin D status groups revealed a high prevalence across all categories. In the deficient group, 63 out of 71 patients (88.73%) were insulin resistant. Similarly, 75 of the 83 patients (90.36%) in the insufficient group and 19 of the 21 patients (90.48%) in the sufficient group were also insulin resistant.

Table 4: Insulin Resistance by Vitamin D Status

Vitamin_D_Status	Not Insulin Resistant	Insulin Resistant	Total	% Insulin Resistant
Deficient	8.0	63.0	71.0	88.73
Insufficient	8.0	75.0	83.0	90.36
Sufficient	2.0	19.0	21.0	90.48

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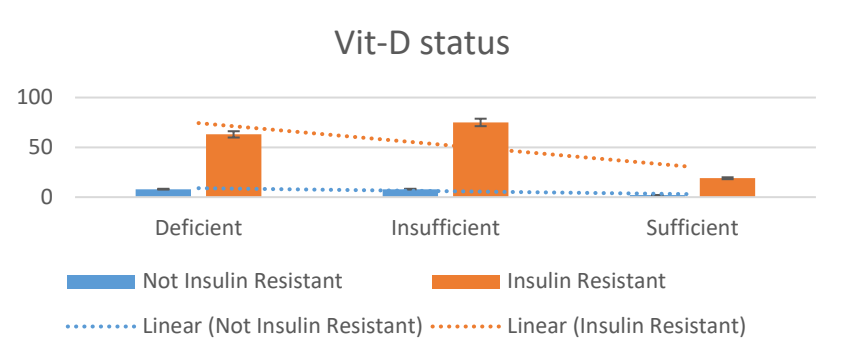

Figure 2: Insulin Resistance by Vitamin D Status

Discussion

The research determined how vitamin D levels associate with insulin resistance in Type 2 diabetes mellitus patients specifically at their initial diagnosis. Research analysis shows that vitamin D deficiency along with insulin resistance affect most people within the study group. The mean HOMA-IR numbers were only somewhat higher among patients with vitamin D deficiency but no statistically significant differences existed between deficient and insufficient and sufficient groups. All patient groups demonstrated insulin resistance according to HOMA-IR values because more than 88% of participants in each category exhibited insulin resistance. Analysis revealed that serum vitamin D levels averaged 21.6 ng/mL within the cohort yet more than 88% of patients displayed insulin resistance because sufficient vitamin D values were detected in only a limited number of participants (12%). Studies have already established that type 2 diabetes patients commonly suffer from hypovitaminosis D because obesity and reduced sun exposure and physical inactivity share these risk factors [15]. Research support through other population studies shows a negative relationship exists between vitamin D levels and insulin resistance yet multiple studies did not reach statistical significance [16].

The weak negative link between blood vitamin D amounts and HOMA-IR results does not confirm that vitamin D functions independently as a leading factor in insulin sensitivity measurement for newly detected patients. Studies have suggested multiple explanations for any potential connection between vitamin D and insulin receptor expression and beta-cell function and inflammatory regulation. This study did not fully control other influencing metabolic factors including dietary habits along with genetic influences and physical activity and obesity which affect these proposed mechanisms. This study discovered that new type 2 diabetes patients with newly diagnosed type 2 diabetes showed no significant relationships between vitamin D serum content levels and HOMA-IR insulin resistance measurements. The insulin resistance levels stayed elevated across all vitamin D measurement categories despite a slight opposite trend. The results match findings from Kumar et al.'s (2024) published randomized controlled trial about vitamin D supplements for newly diagnosed T2DM patients [17]. A clinical study revealed that insulin resistance did not get better after vitamin D treatment though researchers found that vitamin D has metabolic functions but these do not improve insulin sensitivity among patients with new type 2 diabetes. Vitamin D deficiency appears as a contributing element but it does not function alone to determine insulin resistance levels because this condition exists consistently across different vitamin D level groups [18]. The participants likely presented with well-established insulin resistance when diagnosed because their vitamin D status showed no influence on this condition. The research design as cross-sectional limits researchers from establishing direct cause-effect relationships. The number of patients with sufficient vitamin D levels appeared small enough to reduce the ability to detect meaningful statistical differences. Vitamin D dietary intake together with sun exposure and parathyroid hormone level assessment were not included in the evaluation due to potential unmeasured confounding effects.

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Conclusion

It is concluded that vitamin D deficiency is highly prevalent among patients newly diagnosed with type 2 diabetes mellitus; however, no statistically significant association was observed between vitamin D levels and insulin resistance as measured by HOMA-IR. Although a mild inverse trend was noted, insulin resistance was consistently high across all vitamin D status categories, including those with sufficient levels.

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