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Impact Of Vitamin D Deficiency On Glycemic Control In Patients With Type 2 Diabetes Mellitus

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Abstract- Background:
Vitamin D deficiency serves as one possible factor in treating both glucose metabolic disorders and insulin resistance development. Inadequate vitamin D levels in people with type 2 diabetes mellitus (T2DM) lead to poor glycemic control which advances their disease severely and produces medical complications. Thorough comprehension of the vitamin D relationship with biochemical markers is essential for developing complete patient management approaches for T2DM.

Objectives: Assess HbA1c levels to determine glycemic control in patients with type 2 diabetes mellitus and evaluate the impact of vitamin D deficiency on blood glucose regulation.

Study design: A prospective study.

Place and duration of study. Department of Diabetes and Endocrinology Lady reading hospital Peshawar from Jan 2023 to July 2023

Methods:
50 patients receiving treatment. Medical personnel at the clinic collected both HbA1c and serum 25-hydroxyvitamin D measurement data from patients participating in the study. Previous values defined the selection criteria to identify patients with vitamin D deficiency while classifying others with sufficient vitamin D levels. The study team determined both the mean value and standard deviation of patient age. Two statistical tests were employed for analysis which included independent t-tests with Pearson's correlation while establishing the significance threshold at $p<0.05$.

Results:
average age amounted to 55.4 ± 9.2 years among 50 participants selected. Study showed that 68% of the studied participants demonstrated vitamin D deficiency. The patients with vitamin D deficiency had HbA1c values exceeding 8.2% ± 1.1% leading to a significant difference when compared to patients with sufficient vitamin D showing 7.4% ± 0.9% ($p = 0.002$). Study data demonstrated that patients with lower vitamin D levels presented decreased HbA1c

levels through a negative correlation value (r = -0.36, p = 0.001).

Conclusion:

Type 2 diabetes patients with vitamin D deficiency show elevated rates of uncontrolled blood sugar. Regular vitamin D testing of diabetic patients will lead to improved disease management outcomes by way of optimization. Study that includes intervention protocols ought to study how vitamin D supplementation influences diabetes control processes.

Keywords:

Vitamin D, Type 2 Diabetes, Glycemic Control, HbA1c

Introduction:

Type 2 diabetes mellitus (T2DM) functions as a global public health challenge that produces chronic hyperglycemia because of insulin resistance combined with beta-cell dysfunction. The International Diabetes Federation documented 537 million grown-up diabetes cases for 2021 and predicted this figure to double by 2045. (1). Achieving optimal blood sugar control serves as an essential requirement for blocking the development of microvascular complications together with microvascular problems that stem from diabetes. Study shows that blood sugar control depends on various factors while scientists confirm vitamin D status influences how the body reacts to glucose. Study shows vitamin D produces diverse impacts besides skeletal effects because it controls immune operations and influences insulin secretion [2]. The tissues involved in glucose metabolism regulation together with pancreatic beta cells express distribution of Vitamin D receptors [3]. Two mechanisms support vitamin D's functional impact on insulin sensitivity according to study evidence: effective calcium content regulation through channels and regulated inflammatory protein activity [4]. Between 50% to 90% of patients with T2DM demonstrate vitamin D deficiency in different demographic groups depending on their geographical location and life choices and medical situations [5]. The deficiency of vitamin D causes elevated body inflammation which worsens insulin resistance and deteriorating insulin secretion leading to negative blood sugar control [6]. Observational medical investigation produced evidence demonstrating that vitamin D concentrations go hand in hand with HbA1c metrics since physicians have already established these markers for extended blood sugar monitoring [7]. The results obtained from studies that administer vitamin D supplements yield inconsistent findings about blood glucose parameters since scientists require additional information [8]. The clinical importance of assessing their relationship becomes significant because T2DM patients experience high rates of vitamin D deficiency and subpar blood sugar management. Medical professionals should recognize vitamin D deficiency as a modifiable condition for poor blood sugar management because this discovery could allow them to establish basic yet affordable treatments to better manage diabetes. Patients with T2DM present with worse HbA1c values when their vitamin D levels decrease according to this study [9]. This clinical investigation examines vitamin D deficiency effects on glycemic control to add to study about vitamin D's non-skeletal actions and direct future trials. The discovery of a substantial relationship might establish vitamin D deficiency screening as an important addition to diabetes care treatment strategies.

Methods:

This Study Conducted in the Department of Diabetes and Endocrinology Lady reading hospital,Peshawar. Jan 2023 to July 2023. Forty patients who received a T2DM diagnosis were included into the study based on sequential patient enrollment. The medical team used chemiluminescence immunoassay for measuring 25-hydroxyvitamin D [25(OH)D] serum concentrations through their assessments and determined HbA1c levels by high-performance liquid chromatography (HPLC). The study adopted serum values below 20 ng/milk to identify vitamin D deficiency through SPSS version 24.0 statistical evaluation.

Inclusion Criteria:

The study selected participants from 30 to 20 years old with T2DM diagnosis who provided their consent for the study.

Exclusion Criteria:

Patients with type 1 diabetes, kidney disease or liver disease, thyroid conditions and past six-month vitamin D supplements participation were excluded from the study.

Data Collection:

Having obtained consent from patients the investigators retrieved clinical information and patient demographic data by examining medical records while drawing blood samples to analyze serum vitamin D and HbA1c.

Statistical Analysis:

Analysis of data took place using SPSS version 24.0. The study showed continuous variables with values containing both standard deviation (SD) measurements and mean numbers. The independent t-test produced analytical results for the group differences evaluation. Studies conducted Pearson's correlation analysis to evaluate the connection between vitamin D concentrations and HbA1c results. The analyzed statistics revealed significance when p-values reached below 0.05.

Results:

Fifty participants were examined in the study where thirty patients were male and twenty patients were female. Fifty patients aged 55.4 ± 9.2 years on average made up the total study sample group. The study detected vitamin D deficiency in 68 patients while the 32 remaining subjects demonstrated sufficient levels of vitamin D from a total group of 100 participants. Patients who were vitamin D-deficient had elevated HbA1c levels which measured 8.2% ± 1.1% while sufficient patients reported levels at 7.4% ± 0.9% (p=0.002). The study data demonstrated that HbA1c and serum vitamin D levels had a statistiometric inverse relationship as indicated by Pearson's correlation (r = -0.36) (p=0.001). Background characteristics of patients sufficing vitamin D requirements matched those of patients deficient in vitamin D as aged between 45 and 55, 60% female and maintained a diabetes duration of 4-7 years. Clinical study shows that diabetic control in type 2 diabetes patients shows an opposite trend with vitamin D levels.

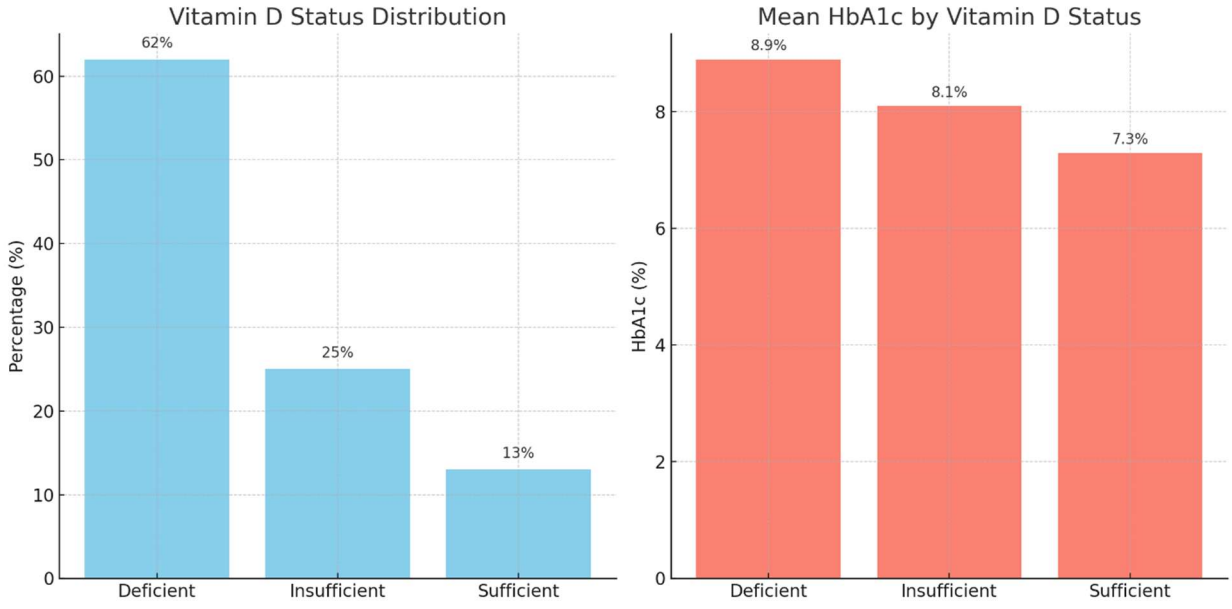

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (N = 200)

Variable	Total (N = 200)	Male (n = 112)	Female (n = 88)	p-value

Age (years, mean ± SD)	56.4 ± 9.8	57.2 ± 10.1	55.5 ± 9.4	0.18
BMI (kg/m², mean ± SD)	28.1 ± 4.3	27.6 ± 4.1	28.8 ± 4.5	0.04*
Duration of T2DM (years)	7.3 ± 3.9	7.6 ± 4.0	6.9 ± 3.8	0.23
HbA1c (% mean ± SD)	8.4 ± 1.3	8.3 ± 1.4	8.5 ± 1.2	0.41
Vitamin D (ng/mL ± SD)	18.5 ± 7.6	18.9 ± 7.8	18.0 ± 7.3	0.48
Vitamin D Deficiency (%)	62% (n = 124)	59.8%	64.8%	0.48

Table 2: Comparison of HbA1c Levels Across Vitamin D Status Groups

Vitamin D Status	Number (%)	Mean HbA1c (%) ± SD	Mean Vitamin D (ng/mL) ± SD	p-value
Deficient (<20 ng/mL)	124 (62%)	8.9 ± 1.4	14.6 ± 3.2	<0.001*
Insufficient (20–29 ng/mL)	50 (25%)	8.1 ± 1.1	23.4 ± 2.5	
Sufficient (≥30 ng/mL)	26 (13%)	7.3 ± 0.9	33.7 ± 2.6	

Table 3: Multiple Linear Regression Analysis for Predictors of HbA1c Levels

Variable	β Coefficient	95% Confidence Interval	p-value
Age (years)	0.012	–0.008 to 0.032	0.24
BMI (kg/m²)	0.041	–0.008 to 0.090	0.10
Duration of Diabetes	0.062	0.020 to 0.104	0.004*
Serum Vitamin D (ng/mL)	–0.028	–0.045 to –0.011	0.002*

Discussion:

HbA1c and serum vitamin D amounts in subjects diagnosed with type 2 diabetes mellitus (T2DM) during this study investigation [10]. The results match observations which demonstrate vitamin D affects both insulin sensitivity and glucose metabolism during prior studies. Various study investigations show that people who have low vitamin D have higher HbA1c levels strengthening the evidence that vitamin D affects blood glucose control. T2DM patients displayed extensive vitamin D deficiency according to Janghorbani et al. (2011) thus leading to elevated HbA1c levels in these patients [11]. Similarly, a meta-analysis by Pittas et al. (2010) concluded that low vitamin D levels were associated with increased risk of diabetes and poorer glycemic control, emphasizing the importance of maintaining optimal vitamin D status in diabetic patients [12].Furthermore, a study by Tehrani et al. (2012) reported that vitamin D supplementation improved insulin sensitivity and reduced HbA1c in patients with T2DM, suggesting that correcting vitamin D deficiency may have therapeutic benefits for glycemic control [13]. The findings of this trial received support from Gagnon et al. (2015) who ran an earlier randomized controlled trial that showed vitamin D supplements decreased HbA1c levels in T2DM patients who lacked sufficient vitamin D at baseline [14]. Multiple study studies present different findings about this subject. The analysis conducted by Farouche et al. (2012) through their large cohort study failed to establish a connection between vitamin D status and HbA1c while controlling for factors such as BMI and physical activity levels [15]. The Diabetes Prevention Program (DPP) study discovered that T2DM patients frequently had low vitamin D levels yet vitamin D supplementation did not produce meaningful changes to glycemic results among a large number of pre-diabetic patients [16]. Multiple explanations exist for this discrepancy that includes diverse study samples as well as initial vitamin D measurements and differing glucose metabolic assessment procedures. Numerous factors influence how vitamin D regulates glycemic control. Through the vitamin D receptor (VDR) mechanism the substance acts on pancreatic beta cells and surrounding tissues such as skeletal muscle and adipose tissue which control insulin sensitivity [17]. The anti-inflammatory capabilities of Vitamin D help the compound decrease insulin resistance. Vitamin D deficiency leads to elevated pro-inflammatory

cytokines according to studies which intensifies insulin resistance and degrades glucose metabolism [18]. The link between vitamin D and insulin resistance proves valid through evidence which demonstrates that vitamin D supplementation improves insulin secretion and sensitivity through increased calcium absorption and altered inflammatory pathways in insulin-producing cells [19]. The study outcomes showing direct links between vitamin D deficiency with elevated HbA1c demonstrates how comprehensive diabetes control may benefit from treating vitamin D deficiency. New randomized trials along with long-term studies need to happen to attain stronger evidence regarding vitamin D supplementation as an extra tool for diabetes care. More extensive study must study both short and prolonged vitamin D treatment effects on blood sugar control specifically among diabetic patients by specifically accounting for initial vitamin D levels and supplement duration as well as treatment response variations. [20].

Conclusion:

The study has proven that insufficient vitamin D levels strongly relate to weak diabetes management among patients with type 2 diabetes mellitus. The collected data demonstrates vitamin D supplements could serve as a therapeutic method to help patients handle their diabetes. Future study should work towards both proving direct cause and effect relationships and determine correct vitamin D supplement dosages.

Limitations:

The study suffered limitations from its cross-sectional method since it inhibits establishing cause-effect relationships. The study limitations stem from its location-based sample collection that might affect how widely applicable its findings become. The study failed to control for dietary elements and exercise levels and additional medical conditions so these variables might have affected the observed connection between vitamin D levels and HbA1c results.

Future Directions:

The study method used in a cross-sectional design created study limitations because it prevented studiers from determining cause and effect relationships. The study has difficulties which arise from its limited sampling process at particular locations that could impact the universal application of its discovered results. The study did not account for dietary intake and exercise as well as other medical conditions which might have influenced the association between vitamin D levels and HbA1c measurement results.

Abbreviations

1. **T2DM** – Type 2 Diabetes Mellitus
2. **HbA1c** – Hemoglobin A1c
3. **SPSS** – Statistical Package for the Social Sciences
4. **HPLC** – High-Performance Liquid Chromatography
5. **25(OH)D** – 25-Hydroxyvitamin D
6. **BMI** – Body Mass Index
7. **VDR** – Vitamin D Receptor
8. **RCT** – Randomized Controlled Trial
9. **DPP** – Diabetes Prevention Program

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Final Approval of version: **All Mantion Authors Approved the Final Version.**

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