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Original Research Article

# Study of Serum Vitamin D and Its Correlation with Glycemic Variability and Insulin Resistance in Prediabetes: A Retrospective Study

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**Abstract:**

**Background:** Prediabetes represents an intermediate metabolic state characterized by impaired glucose regulation and heightened risk of progression to type 2 diabetes mellitus. Emerging evidence suggests that vitamin D deficiency may contribute to dysglycaemia and insulin resistance through its effects on pancreatic β-cell function, insulin sensitivity and systemic inflammation. However, data examining this association in Indian prediabetic populations remain limited.

**Materials and Methods:** This retrospective study was conducted at Patna Medical College, Patna, Bihar, over a period of eight months. Medical records of adults diagnosed with prediabetes who had documented serum 25-hydroxyvitamin D levels and glycaemic parameters were reviewed. Insulin resistance was assessed using the Homeostatic Model Assessment of Insulin Resistance (HOMA-IR), and glycaemic variability was evaluated using fasting plasma glucose and postprandial glucose measurements. Correlations between serum vitamin D levels, insulin resistance and glycaemic variability were analysed.

**Results:** Among the study population, vitamin D deficiency was highly prevalent. Lower serum vitamin D levels were significantly associated with higher HOMA-IR values and greater glycaemic variability. Patients with sufficient vitamin D status demonstrated comparatively better insulin sensitivity and more stable glycaemic parameters.

**Conclusion:** Serum vitamin D deficiency is significantly associated with increased insulin resistance and glycaemic variability in individuals with prediabetes. These findings highlight the potential role of vitamin D status in early dysglycaemic states and support consideration of vitamin D assessment as part of comprehensive metabolic risk evaluation in prediabetes.

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## Introduction

Prediabetes is a metabolic condition defined by glucose levels above normal but below the diagnostic threshold for diabetes mellitus. It includes impaired fasting glucose, impaired glucose tolerance or elevated glycated haemoglobin and is associated with a substantial risk of progression to type 2 diabetes and cardiovascular disease [1]. The prevalence of prediabetes has risen sharply in India over the past decade, driven by rapid urbanization, sedentary lifestyles and increasing obesity.

Insulin resistance is the central pathophysiological abnormality underlying prediabetes and plays a pivotal role in the transition from normoglycaemia to overt diabetes. Glycaemic variability, reflecting fluctuations in blood glucose levels, has gained increasing attention due to its association with oxidative stress, endothelial dysfunction and early vascular complications, even in individuals without established diabetes [2].

Vitamin D, traditionally recognized for its role in calcium homeostasis and bone metabolism, has been increasingly implicated in glucose metabolism and insulin action. Vitamin D receptors are expressed in pancreatic β-cells, adipose tissue and skeletal muscle, suggesting a role in insulin secretion and sensitivity [3]. Vitamin D deficiency is highly prevalent in India despite abundant sunlight, attributed to lifestyle factors, skin pigmentation, dietary insufficiency and limited sun exposure [4].

Several observational studies have reported an inverse association between serum vitamin D levels and insulin resistance, impaired glucose tolerance and risk of type 2 diabetes [5,6]. Vitamin D is thought to influence glucose metabolism through

modulation of insulin receptor expression, suppression of systemic inflammation and regulation of intracellular calcium, which is essential for insulin-mediated glucose transport [7]. However, evidence specifically examining the relationship between vitamin D status, glycaemic variability and insulin resistance in prediabetic individuals remains scarce, particularly in eastern India.

The present study was therefore undertaken to evaluate serum vitamin D levels and their correlation with glycaemic variability and insulin resistance in patients with prediabetes attending a tertiary care centre in Bihar.

## Materials and Methods

This retrospective observational study was conducted at Patna Medical College, Patna, Bihar, a tertiary care teaching hospital serving a large and diverse population. The study duration was eight months.

Medical records of adult patients aged eighteen years and above who had been diagnosed with prediabetes and had documented serum 25-hydroxyvitamin D levels were reviewed. Prediabetes was defined according to standard criteria, including impaired fasting glucose, impaired glucose tolerance or glycated haemoglobin values in the prediabetic range. Patients with established diabetes mellitus, chronic kidney disease, liver disease, malabsorption syndromes or those receiving vitamin D supplementation were excluded.

Demographic details, anthropometric measurements and biochemical parameters were extracted from records. Serum vitamin D levels were categorized as deficient, insufficient or sufficient according to accepted cut-off values. Fasting plasma glucose, postprandial glucose and fasting insulin levels were recorded. Insulin resistance was calculated using the Homeostatic Model Assessment of Insulin Resistance formula. Glycaemic variability was assessed using fasting and postprandial glucose values.

Statistical analysis was performed using standard statistical software. Continuous variables were expressed as mean and standard deviation. Correlations between vitamin D levels, HOMA-IR and glycaemic parameters were analysed using correlation coefficients, with statistical significance defined as a p-value less than 0.05.

## Results

The study included one hundred patients with prediabetes. The majority of participants were middle-aged, with a slight male predominance. Vitamin D deficiency was observed in a substantial proportion of patients, while a smaller fraction had sufficient serum vitamin D levels.

**Table 1: Serum Vitamin D Status and Insulin Resistance in Prediabetes (n = 100)**

| Serum vitamin D status | Number of patients (n) | Mean HOMA-IR ± SD |
|---|---|---|
| Deficient | 46 | 3.4 ± 0.5 |
| Insufficient | 34 | 2.6 ± 0.4 |
| Sufficient | 20 | 1.9 ± 0.3 |

Patients with vitamin D deficiency demonstrated significantly higher fasting glucose levels, greater postprandial glucose excursions and elevated HOMA-IR values compared to those with sufficient vitamin D levels. A clear inverse relationship was observed between serum vitamin D concentration and insulin resistance. As vitamin D status improved from deficient to sufficient, mean HOMA-IR values showed a progressive decline.

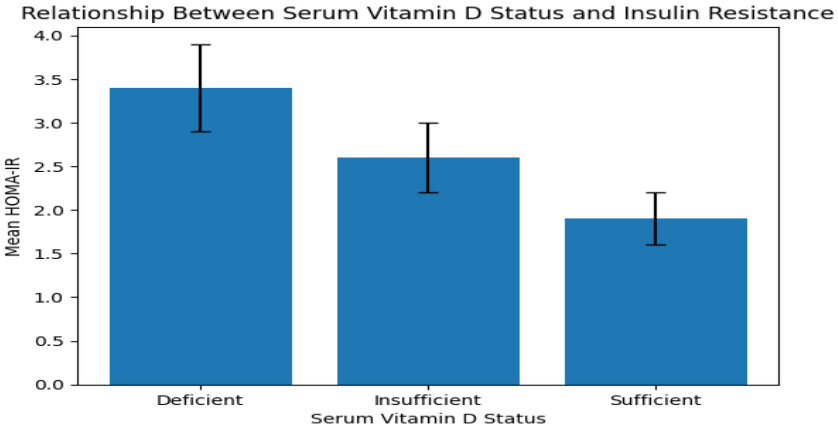


**Figure 1: Relationship between serum vitamin D status and insulin resistance.**

The figure illustrates a progressive decline in mean HOMA-IR values with improvement in serum vitamin D status, indicating reduced insulin resistance among individuals with sufficient vitamin D levels. Error bars represent standard deviation.

Similarly, glycaemic variability was greater among vitamin D deficient individuals, indicating less stable glucose homeostasis. Correlation analysis confirmed that lower serum vitamin D levels were significantly associated with higher insulin resistance and increased glycaemic variability.

## Discussion

The present study demonstrates a significant inverse association between serum vitamin D levels and insulin resistance in individuals with prediabetes. In addition, lower vitamin D levels were associated with greater glycaemic variability, suggesting poorer glucose regulation even before the onset of overt diabetes.

These findings are consistent with earlier studies that reported an association between hypovitaminosis D and impaired glucose metabolism. Pittas and colleagues observed that lower vitamin D levels were associated with increased insulin resistance and higher risk of progression to type 2 diabetes [5]. Similarly, Chiu et al. demonstrated a positive association between serum vitamin D concentrations and insulin sensitivity in glucose-tolerant individuals [6].

The biological mechanisms linking vitamin D deficiency to insulin resistance are multifactorial. Vitamin D enhances insulin receptor expression and improves insulin responsiveness for glucose transport. It also exerts anti-inflammatory effects that may reduce chronic low-grade inflammation, a key contributor to insulin resistance [7]. Additionally, vitamin D influences intracellular calcium regulation, which is essential for insulin secretion and action.

In the Indian context, where vitamin D deficiency is widespread, these findings carry important public health implications. Early identification and correction of vitamin D deficiency in prediabetes may represent a low-cost strategy to improve insulin sensitivity and potentially delay progression to diabetes. However, longitudinal and interventional studies are required to establish causality.

The retrospective nature of the study limits causal inference, and reliance on single-point biochemical measurements may not fully capture long-term glycaemic variability. Nevertheless, the study provides valuable regional data and supports the growing evidence linking vitamin D status with metabolic health.

## Conclusion

This retrospective study demonstrates that serum vitamin D deficiency is significantly associated with increased insulin resistance and greater glycaemic variability in individuals with prediabetes. The findings suggest that vitamin D status may play an important role in early dysglycaemic states and metabolic regulation. Routine assessment of vitamin D levels in prediabetic patients may aid in comprehensive risk stratification and early preventive strategies.

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