

## Original Research Article

# Association between serum vitamin D levels and insulin resistance among adults

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## ABSTRACT

**Background:** Vitamin D is increasingly recognized for its role beyond bone metabolism, particularly in glucose homeostasis and insulin sensitivity. Deficiency of vitamin D has been implicated in the development of insulin resistance, a key pathophysiological mechanism underlying type 2 diabetes mellitus. Several studies have demonstrated a relationship between low Vitamin D levels and metabolic dysfunction. This study aimed to assess the association between serum vitamin D levels and insulin resistance among adults.

**Methods:** A hospital-based cross-sectional study was conducted among 120 adults aged 20-60 years. Serum 25-hydroxyvitamin D, fasting blood glucose, and fasting insulin levels were measured. Insulin resistance was calculated using HOMA-IR. Participants were categorized into vitamin D deficient and sufficient groups. Statistical analysis included descriptive statistics, independent t-test, Pearson correlation, chi-square test, and regression analysis.

**Results:** Vitamin D deficiency was observed in 56.7% of participants. Individuals with vitamin D deficiency had significantly higher fasting insulin and HOMA-IR values. A significant inverse correlation was found between vitamin D levels and insulin resistance ( $r = -0.52$ ,  $p < 0.001$ ), consistent with previous studies. Regression analysis identified vitamin D as an independent predictor of insulin resistance.

**Conclusions:** Vitamin D deficiency is significantly associated with increased insulin resistance. Early identification and correction of Vitamin D deficiency may help reduce metabolic risk.

**Keywords:** Glucose metabolism, HOMA-IR, Insulin resistance, Type 2 diabetes mellitus, Vitamin D deficiency

## INTRODUCTION

Vitamin D, a fat-soluble secosteroid hormone, is essential for calcium and phosphate homeostasis and bone health. In addition to its classical functions, vitamin D has been shown to exert multiple extra-skeletal effects, including modulation of immune function and metabolic regulation. Vitamin D receptors are present in pancreatic  $\beta$ -cells and insulin-sensitive tissues such as skeletal muscle and

adipose tissue, indicating a potential role in glucose metabolism.<sup>1</sup>

Insulin resistance is characterized by reduced responsiveness of peripheral tissues to insulin, resulting in impaired glucose uptake and compensatory hyperinsulinemia. It is a major contributor to the development of type 2 diabetes mellitus and is closely associated with obesity and metabolic syndrome.<sup>2</sup> Several mechanisms have been proposed to explain the

relationship between vitamin D deficiency and insulin resistance. Vitamin D enhances insulin secretion by regulating intracellular calcium levels and improves insulin sensitivity by modulating inflammatory pathways and insulin receptor expression. Additionally, vitamin D deficiency has been linked to chronic low-grade inflammation, which contributes to insulin resistance.

Globally, vitamin D deficiency is highly prevalent, even in sun-rich countries like India, due to lifestyle factors and limited sun exposure.<sup>3</sup> At the same time, the prevalence of insulin resistance and type 2 diabetes mellitus is rising rapidly, posing a major public health concern.

Numerous studies have reported an inverse relationship between serum vitamin D levels and insulin resistance. Chiu et al demonstrated that lower vitamin D levels are associated with increased insulin resistance and  $\beta$ -cell dysfunction. Pittas et al reported a significant role of vitamin D in glucose metabolism.<sup>2</sup> Other observational and epidemiological studies have further confirmed this association.<sup>4,5</sup>

Systematic reviews and meta-analyses have also provided strong evidence supporting the association between vitamin D deficiency and insulin resistance across diverse populations.<sup>6</sup>

In this context, the present study was undertaken to evaluate the association between serum vitamin D levels and insulin resistance among adults.

## METHODS

The present study was a hospital-based cross-sectional observational study conducted in the Department of Medicine of Sri Lakshmi Narayana Medical College over a period of six months. A total of 120 adult participants aged between 20 and 60 years were enrolled after obtaining informed consent. Participants were selected based on predefined inclusion and exclusion criteria. Individuals with known diabetes mellitus, chronic kidney disease, chronic liver disease, thyroid disorders, or those receiving vitamin D supplementation were excluded to minimize confounding factors.

All participants underwent detailed clinical evaluation including history and physical examination. Anthropometric parameters such as age and body mass index (BMI) were recorded. Blood samples were collected after an overnight fast of 8-10 hours. Serum 25-hydroxyvitamin D levels were measured using standardized laboratory techniques. Fasting blood glucose was estimated by the glucose oxidase method, and fasting serum insulin levels were measured using immunoassay methods.

Participants were categorized into two groups based on serum vitamin D levels: deficient (<20 ng/ml) and sufficient ( $\geq$ 20 ng/ml). Insulin resistance was calculated

using the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR), derived using the formula: fasting insulin multiplied by fasting glucose divided by 405.

## Statistical analysis

Data were analyzed using the SPSS software. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages. An independent t-test was used to compare means between groups. Pearson correlation analysis was applied to assess the relationship between vitamin D levels and insulin resistance. Chi-square test was used for categorical comparisons. Multiple linear regression analysis was performed to determine independent predictors of insulin resistance. A p value of less than 0.05 was considered statistically significant.

## RESULTS

A total of 120 participants were included, with a mean age of 42.3 $\pm$ 10.2 years. Among them, 68 (56.7%) were vitamin D deficient (Table 1).

**Table 1: Demographic characteristics of study participants (n=120).**

Parameters	Value (%)
Age (years)	42.3 $\pm$ 10.2
<b>Gender</b>	
Male	68 (56.7)
Female	52 (43.3)
Total	120 (100)

The mean serum vitamin D level was 16.8 $\pm$ 4.2 ng/ml in the deficient group and 28.6 $\pm$ 5.1 ng/ml in the sufficient group (Table 2 and 3).

**Table 2: Distribution of participants according to vitamin D status (n=120).**

Vitamin D status	Frequency	Percentage
<b>Deficient (&lt;20 ng/ml)</b>	68	56.7
<b>Sufficient (<math>\geq</math>20 ng/ml)</b>	52	43.3
<b>Total</b>	120	100

Fasting insulin levels were significantly higher in the vitamin D deficient group (14.5 $\pm$ 3.8  $\mu$ IU/mL) compared to the sufficient group (9.8 $\pm$ 2.6  $\mu$ IU/ml) (p<0.001) (Table 3).

Similarly, HOMA-IR values were significantly elevated in the deficient group (3.8 $\pm$ 1.2) compared to the sufficient group (2.1 $\pm$ 0.9) (p<0.001) (Table 3).

A significant negative correlation was observed between serum vitamin D levels and HOMA-IR (r= -0.52, p<0.001) (Table 4).

**Table 3: Status comparison of biochemical parameters (n=120).**

Parameter	Vitamin D deficient (n=68)	Vitamin D sufficient (n=52)	P value
<b>Vitamin D (ng/mL)</b>	16.8±4.2	28.6±5.1	<0.001*
<b>Fasting glucose (mg/dL)</b>	102.4±12.6	94.8±10.3	0.002*
<b>Fasting insulin (µIU/mL)</b>	14.5±3.8	9.8±2.6	<0.001*
<b>HOMA-IR</b>	3.8±1.2	2.1±0.9	<0.001*

\*Significant

**Table 4: Correlation analysis.**

Parameter	Correlation coefficient (r)	P value
<b>Vitamin D vs HOMA-IR</b>	-0.52	<0.001*
<b>Vitamin D vs Fasting insulin</b>	-0.48	<0.001*

Regression analysis showed vitamin D as an independent predictor

Regression analysis demonstrated that vitamin D levels were an independent predictor of insulin resistance after adjusting for age and BMI (Table 5 and 6). Insulin resistance was significantly more prevalent in vitamin D deficient individuals.

**Table 5: Regression analysis.**

Parameter	β	P value
<b>Vitamin D</b>	-0.45	<0.001
<b>BMI</b>	0.38	<0.001

**Table 6: Association of vitamin d with insulin resistance.**

Group	IR present	IR absent
<b>Deficient</b>	46	22
<b>Sufficient</b>	14	38

Chi-square test showed a significant association (p&lt;0.001)

## DISCUSSION

The present study demonstrated a significant inverse association between serum vitamin D levels and insulin resistance. Individuals with vitamin D deficiency exhibited higher fasting insulin levels and elevated HOMA-IR values, indicating impaired insulin sensitivity.

These findings are consistent with earlier studies. Chiu et al reported that hypovitaminosis D is associated with increased insulin resistance and β-cell dysfunction.<sup>1</sup> Similarly, Pittas et al highlighted the role of vitamin D in glucose metabolism and insulin sensitivity.<sup>2</sup> George et al further demonstrated that vitamin D supplementation improves glycaemic control.<sup>3</sup>

Other studies have supported these findings. Kayaniyil et al reported an association between vitamin D deficiency and β-cell dysfunction.<sup>4</sup> Scragg et al observed that low vitamin D levels were associated with an increased risk of

diabetes.<sup>5</sup> Ford et al showed a significant relationship between vitamin D status and metabolic syndrome.<sup>7</sup>

The biological mechanisms underlying this association include the role of vitamin D in calcium homeostasis, insulin receptor gene expression, and modulation of inflammatory cytokines.<sup>8,9</sup> Vitamin D also improves insulin sensitivity by reducing systemic inflammation.<sup>10,11</sup>

Systematic reviews and meta-analyses have further confirmed that vitamin D deficiency is significantly associated with insulin resistance and metabolic dysfunction across different populations.<sup>12</sup>

Despite these findings, the cross-sectional nature of the study limits the ability to establish causality. Longitudinal studies and randomized controlled trials are required to further clarify the role of vitamin D in insulin resistance and metabolic disorders.

## CONCLUSION

The present study demonstrates a significant inverse association between serum vitamin D levels and insulin resistance among adults, with vitamin D deficient individuals showing higher fasting insulin levels and elevated HOMA-IR values. Vitamin D was identified as an independent predictor of insulin resistance even after adjusting for confounding factors such as age and body mass index, suggesting a direct role in glucose metabolism. These findings indicate that vitamin D deficiency may act as a modifiable risk factor for insulin resistance and related metabolic disorders, including type 2 diabetes mellitus. Therefore, routine screening and timely correction of vitamin D deficiency may help in early identification and prevention of metabolic complications, although further longitudinal and interventional studies are required to establish causality and evaluate the therapeutic benefits of supplementation.

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