



## Role of Vitamin D in Controlling Blood Sugar and Blood Lipid Levels in Patients with Type 2 Diabetes

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### Abstract

Vitamin D deficiency is increasingly associated with metabolic disorders such as insulin resistance, diabetes, and dyslipidemia. These disorders are very common today due to poor dietary habits and certain metabolic diseases. The aim of the study was to assess the association between vitamin D levels and metabolic indicators, such as, insulin, glycated hemoglobin (HbA1c) and blood lipid values in diabetic and prediabetic patients. Laboratory data were used to conduct a cross-sectional research. Statistical analysis involved analysis of variance (ANOVA) to compare groups and Pearson correlation coefficient to determine relationships between variables. There was a great difference in the levels of vitamin D between the sexes ( $F = 7.83$ ,  $p = 0.010$ ). A strong negative correlation was also found between vitamin D and insulin ( $r = -0.73$ ). Moreover, there was a significant positive correlation between age and glycated hemoglobin ( $r = 0.74$ ) as well as LDL cholesterol and total cholesterol ( $r = 0.81$ ). Vitamin D deficiency is strongly associated with insulin resistance and metabolic disorders, which emphasize its possible involvement in metabolic health.

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### Introduction

Type 2 diabetes is a common chronic disease, affecting more than 530 million people worldwide, its prevalence has more than doubled in the last two decades, and its incidence continues to rise at an alarming rate, this disease places a heavy burden on both individuals and society, as its long-term complications pose significant challenges to public health and healthcare system (Vuong *et al.*, 2025) <sup>[27]</sup>. Prediabetes, the precursor stage between standard blood glucose levels and diabetes is estimated to impact about 541 million individuals, or 10.6% of the global population, by 2021, This figure is set to rise to 11.4%, or 730 million people, by the 2030s. It is necessary to note, though, that these numbers might be lower estimates (Md Isa *et al.*, 2023; Vuong *et al.*, 2025) <sup>[27]</sup>. The lifestyle change to high-energy diets and sedentary lifestyles are some of the main factors that have contributed to the rise in the prevalence of diabetes and prediabetes (Basu *et al.*, 2013) <sup>[5]</sup>. Thus, it is important to diagnose diabetes and prediabetes early so that it is possible to prevent vascular complications and intervene early enough, this is the reason why the American Diabetes Association (ADA) suggests screening of patients at risk of developing diabetes and prediabetes (Alliance, 2018). Among the most significant factors related to early prevention of prediabetes, insulin resistance and the related vitamin deficiencies, especially vitamin D deficiency, should be mentioned (Nakashima *et al.*, 2016 ; Al-Hetar *et al.*, 2025 ; Derbel *et al.*, 2025 ; Gandhe *et al.*, 2013).013) <sup>[20, 10]</sup>.

Vitamin D is a fat-soluble vitamin that is crucial in the metabolism of the bones, as well as in many other metabolic processes (Al-Hetar *et al.*, 2025) <sup>[3]</sup> (Saif-Elnasr *et al.*, 2017) <sup>[25]</sup> (Md Isa *et al.*, 2023). It has as well a dual origin: exogenous, which refers to the intake of it through the diet, but also endogenous, as it is neo synthesized in the epidermis, This vitamin is carried in the human plasma by binding proteins:85% is bound to Vitamin D binding protein 15% is bound to albumin (Derbel *et al.*, 2025) <sup>[7]</sup>. Recent researches have emphasized its involvement in glucose metabolism, insulin sensitivity and lipid regulation (Jain *et al.*, 2025) <sup>[12]</sup>

(Mirhosseini *et al.*, 2018) [18]. One of the main characteristics of metabolic syndrome is insulin resistance, which is strictly related to type 2 diabetes and cardiovascular disease (Al-Hetar *et al.*, 2025; Pan *et al.*, 2016) [3, 22]. In the same manner, dyslipidemia, which is an increase in LDL cholesterol levels and triglyceride levels, and a decrease in HDL cholesterol levels is also a major risk factor to cardiovascular complications. Recent findings indicate that the lack of vitamin D can be one of the factors behind these metabolic disorders (Md Isa *et al.*, 2023) (Huang *et al.*, 2023) [11]. Thus, this research will explore the connection between the level of vitamin D and the major metabolic markers, such as insulin, glycated hemoglobin (HbA1c), and blood lipid levels in diabetic and prediabetic patients.

### Materials and methods

**Collection of samples:** Blood samples (serum and whole blood) were collected from specialized medical laboratories for the patients targeted in this study, taking into consideration that the fasting period for patients should be 12 hours.

**Parameters estimation:** VIDAS 25-hydroxyvitamin D (25(OH)D)<sup>TM</sup> automated immunoassay system (bioMerieux, Marcy-l-Etoile, France) is a highly-sensitive automated vitamin D assay and the results were obtained by following the manufactures instructions .

HbA1c levels were measured by full automated ABBOTT Afinion<sup>TM</sup> 2 Analyzer (Abbott Laboratories, Abbott. Park, IL, USA) as per the manufactures instructions, Afinion.

The manufacturer (Cobas e 411, Roche Diagnostics, Mannheim, Germany) measured serum levels of insulin with the Cobas e 411 analyzer, as per the instructions.

The serum biomarkers (cholesterol, triglyceride, HDL, LDL and FBS) were quantified on an automated biochemical analyzer system (FUJI DRI-CHEM NX500i, Fujifilm Corporation, Tokyo, Japan) as per the instructions of the manufacturer.

### Result

This was done in about (75) participants who were female and had diabetes and the other participants who had prediabetes and signs of insulin resistance. The measurements of FBS, HbA1c, and insulin were done to verify the findings of diabetes and prediabetes. Lipid profile (contained: total Cholesterol, Triglycerides, HDL, LDL) tests and vitamin D level tests were also done. The sample was further categorized into three groups of participants with sufficient, deficient and insufficient vitamin D. The results were analyzed and interpreted through statistical tests which included One-way-ANOVA and Pearson correlation coefficient.

The results of this study showed highly significant differences in insulin levels among the vitamin D groups ( $p=0.0001$ ), indicating a clear effect of vitamin D levels on blood insulin concentration.

HDL levels also showed a value close to statistical significance ( $p=0.056$ ), suggesting a possible trend toward difference, but not reaching statistical significance. The LSD and Duncan insulin level tests showed significant differences between the adequate vitamin D group and both the vitamin D deficiency group and the insufficient vitamin D group. This indicates a clear decrease in insulin levels among individuals in the adequate vitamin D group Table (1).

**Table 1:** Comparison Among Parameters and Study Groups of Vitamin D.

Parameter	Study group			F-value	p-value
	Deficient (Mean±SD)	Insufficient (Mean±SD)	Sufficient (Mean±SD)		
insulin	27.83±5.95	24.71±3.45	14.80±4.21	11.88	0.0001*
HbA1c	6.06±0.72	6.19±1.18	5.44±0.32	1.33	0.287
LDL	115.67±50.63	105.71±30.69	106±18.95	0.17	0.843
HDL	48.58±10.29	43.29±12.93	33.4±10.29	3.31	0.056
TG	152.17±63.62	128.57±76.05	193.4±65.35	1.34	0.282
Cholesterol	203.75±47.33	180.14±32.22	180.2±38.63	0.97	0.396

The Pearson correlation coefficient showed that vitamin D and insulin levels are strongly negatively correlated ( $r = -0.73$ ), indicating that low levels of vitamin D are positively related with high levels of insulin. On the same note, there was also a significant positive correlation between age and HbA1c ( $r = 0.74$ ), and thus worsening blood sugar control

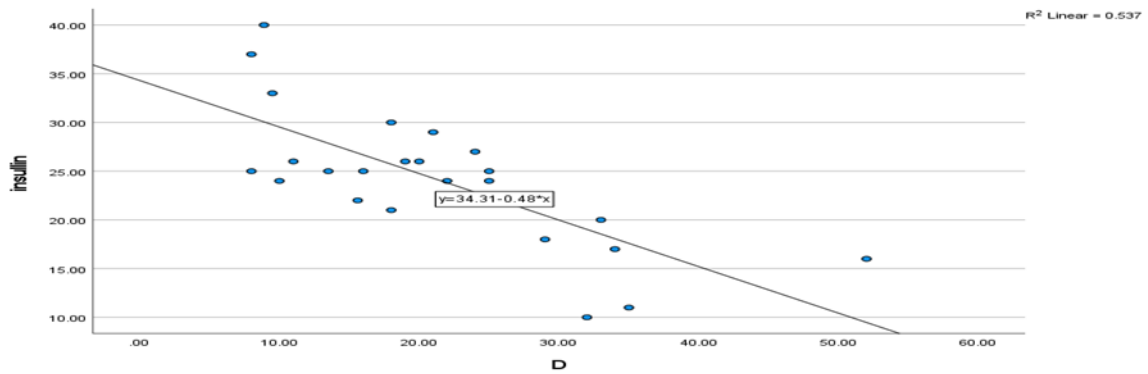
with age. There was also a significant positive correlation between LDL cholesterol and the total cholesterol ( $r = 0.81$ ) indicating the important role of LDL cholesterol in the determination of the cholesterol levels in the total cholesterol table (2) and figure (1).

**Table 2:** Correlation Among Vitamin D, FBS, Insulin, HbA1c and Lipid Profile.

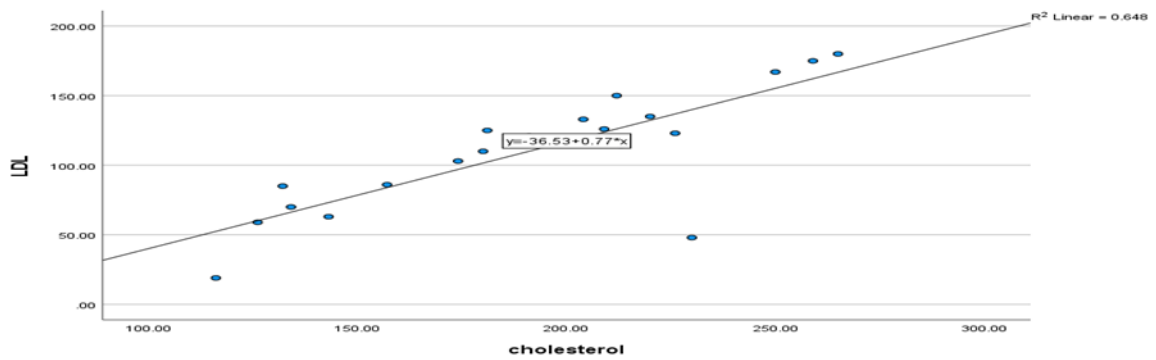
Correlation	Vit. D	Insulin	Cholesterol	TG	HDL	LDL	FBS	HbA1c
Vit. D	1							
Insulin	-0.733**	1						
Cholesterol	-0.193	0.151	1					
TG	0.053	-0.076	0.242	1				
HDL	-0.373	0.294	0.206	-0.315	1			
LDL	-0.031	-0.007	0.805**	0.085	0.186	1		
FBS	-0.390	0.565**	-0.042	-0.219	0.256	-0.126	1	
HbA1c	-0.253	0.447*	-0.274	-0.125	-0.031	-0.390	0.072	1

\* Correlation is significant at the 0.05 level (2-tailed)

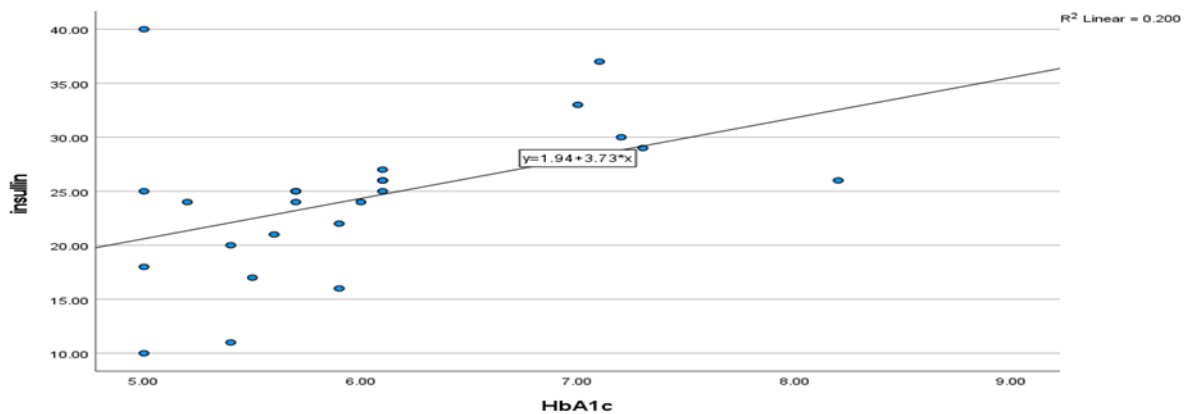
\*\* correlation is significant at the 0.01 level (2-tailed)



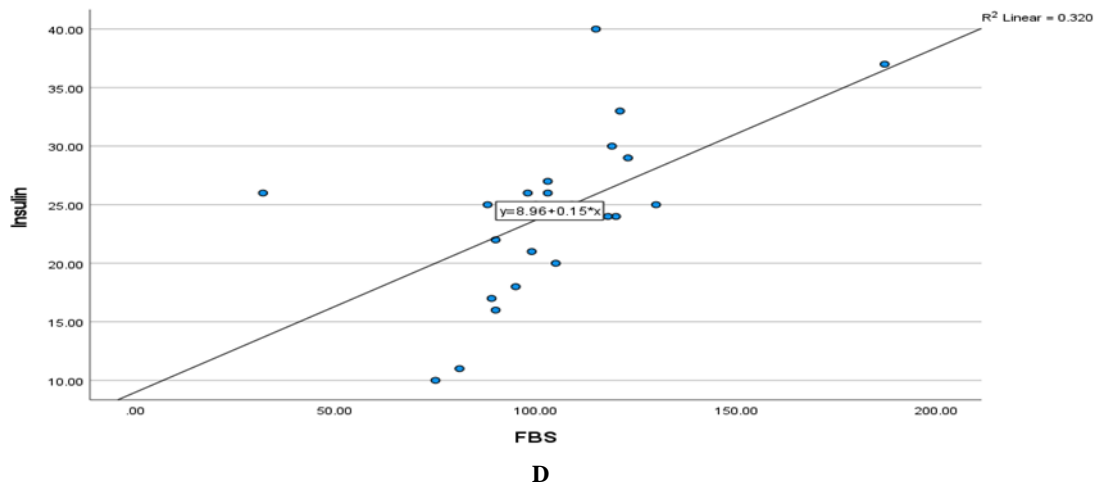
A



B



C



**Fig 1:** A: Correlation between Insulin & vitamin D ( $p < 0.001$ )  
 B: Correlation Between LDL & Cholesterol ( $p < 0.01$ )  
 C: Correlation Between Insulin & HbA1c ( $p = 0.029$ )  
 D: Correlation Between Insulin & FBS ( $p = 0.004$ )

## Discussion

Vitamin D, also known as the “sunshine vitamin,” which the body obtains from natural food sources or through supplements (Pittas *et al.*, 2019) [24], is a vital nutrient whose importance extends beyond bone health to include a pivotal role in regulating many physiological processes in the body, particularly in individuals with obesity and diabetes (Karau *et al.*, 2019) [13]. Studies have shown that this vitamin contributes directly and indirectly to influencing metabolism (Pan *et al.*, 2016) [22], insulin sensitivity, and reducing complications associated with chronic diseases. This research gives support to the fact that vitamin D levels are strongly correlated with insulin resistance, and have only slight impacts on other metabolic markers. The main study finding was that there was a huge difference among the vitamin D groups in insulin levels which was found to be significant using ANOVA and post-hoc analyses. The significant decrease of insulin concentration in the group that consumed sufficient amounts suggests the presence of better insulin sensitivity, which supports the hypothesis that vitamin D is involved in glucose metabolism, the latter finding is also supported by earlier studies suggesting that vitamin D enhances the expression of insulin receptors and beta cell functioning in

Surprisingly, there were no statistically significant differences in the glycated hemoglobin (HbA1c) levels between the groups. This is because glycated hemoglobin (HbA1c) indicates how well blood glucose levels are controlled over the long term, whereas vitamin D may have a shorter-term or instant impact on insulin response compared to the chronic control of glucose levels. There is also evidence of strong correlation between vitamin D deficiency and high levels of HbA1c, and people with sufficient vitamin D levels tend to have better glycemic control (Olt, 2015) (Jain *et al.*, 2025) [12] (Mirhosseini *et al.*, 2018) [18].

Analysis of lipid profile showed that there were no statistically significant differences in triglycerides or total cholesterol, which is in line with the fact that lipid metabolism is affected by a variety of factors, including, but

not limited to, diet, physical activity, and genetic predisposition. As such, the effect of vitamin D alone on lipid markers might not be significant, as vitamin D is a fat-soluble. This is the so-called fat trap, when the presence of the essential vitamin is lowered, although it is stored in the body in its amounts (Derbel *et al.*, 2025; Pan *et al.*, 2016) [7, 22]. In turn, in such a case, patients tend to have an increased need of vitamin D to obtain sufficient blood levels (Mirhosseini *et al.*, 2018) [18] (Derbel *et al.*, 2025) [7]. Conversely, deficiency in vitamin D is linked with a higher rate of lipogenesis, whereas sufficient levels might help to achieve greater energy efficiency and less fat buildup (Huang *et al.*, 2023) (Pan *et al.*, 2016). [11, 22]

Vitamin D is an important factor in regulating lipid metabolism in patients with type 2 diabetes, recent evidence indicates that its deficiency is associated with a marked disruption in the lipid profile and an increased risk of cardiovascular complications (ElSayed *et al.*, 2022) [9] (Mlynarska *et al.*, 2025) [19]. Vitamin D helps to lower lipogenesis and enhance lipolysis in fat cells and its deficiency results in more fat being stored, particularly in the visceral fat, which correlates with insulin resistance (Md Isa *et al.*, 2023). It also indirectly contributes to enhancing insulin sensitivity which has a positive effect on reducing fat production in the liver and decreasing levels of triglycerides, as well as improving lipoprotein balance, increasing good cholesterol (HDL) and reducing bad cholesterol (LDL) (Huang *et al.*, 2023) [1].

Moreover, vitamin D possesses anti-inflammatory properties, and it lowers secretion of inflammatory cytokines which cause lipid metabolism disorders. This is noteworthy considering that type 2 diabetes is linked to chronic inflammatory condition (Mirhosseini *et al.*, 2018). It has also been shown that the risk of non-alcoholic fatty liver disease is higher in the case of vitamin D deficiency because of the amplified fat production and poor regulation of fat in the liver (ElSayed *et al.*, 2023) [9]. In general, adequate vitamin D levels are associated with improved lipid profiles and a reduced risk of atherosclerosis, while deficiency exacerbates

lipid disorders and increases the risk of cardiovascular disease in diabetic patients (Zoppini *et al.*, 2015 ; Lu *et al.*, 2024)<sup>[29]</sup>.

On the other hand, the effects of vitamin D extend beyond its impact on lipid levels in diabetic patients to include the prevention of diabetic complications, its severe deficiency leads to an increased risk of diabetic foot ulcers, in addition to slowing down the wound healing process, which poses a major challenge in managing the disease (Dai *et al.*, 2020)<sup>[6]</sup>. It also plays a role in protecting the retina from damage, which may reduce the likelihood of diabetic retinopathy, and it contributes to relieving nerve pain associated with diabetic neuropathy (Ahmed *et al.*, 2020; Yuan *et al.*, 2019)<sup>[2, 28]</sup> as well as improving cognitive function (Parveen *et al.*, 2019)<sup>[23]</sup>.

Vitamin D's effects extend beyond physiological aspects to include psychological well-being and quality of life, it has been observed that diabetic patients deficient in this vitamin are more prone to depression and anxiety. Conversely, correcting this deficiency can contribute to improved mood, increased physical activity, and enhanced ability to perform daily activities efficiently, leading to an overall improvement in quality of life (Aghamohammadzadeh *et al.*, 2020; Samefors *et al.*, 2020)<sup>[1, 26]</sup>.

### Conclusion

In conclusion, vitamin D deficiency appears to be closely associated with insulin resistance and metabolic disorders, and these findings highlight the importance of monitoring vitamin D levels as part of the clinical assessment of patients at risk of metabolic syndrome and related disorders.

### Limitations

This study suffers from limitations in its cross-sectional design and the failure to control for influencing factors such as diet, physical activity, and sun exposure. Furthermore, single-tested measurements may not accurately reflect long-term changes.

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