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Association Between Serum Vitamin D Levels and Severity of Hypertension in Adult Patients: A Comparative Study

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Dr Muhammad Zubair[1], Dr Adnan Jahangir[2], Dr Hub E Ali[3], Dr Tahmoor Ghori[4], Dr Ahmad Haroon[5], Dr Danish Marwat[6]

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[1]**Assistant Professor Medicine, Gomal Medical College, Dera Ismail Khan**

[2]**Associate professor, Nishtar University Hospital Multan**

[3]**Assistant professor, Mayo Hospital, Lahore**

[4]**Professor of Medicine, Bolan Medical College, Quetta**

[5]**Professor of Medicine, Sandaman Provincial Hospital Quetta**

[6]**Assistant Professor, Hayatabad Medical Complex, Peshawar**

ABSTRACT:

Background: Hypertension had remained a major global public health problem and had been associated with multiple modifiable and non-modifiable risk factors. Recent evidence had suggested a possible relationship between serum vitamin D levels and blood pressure regulation, but the association with hypertension severity had remained controversial.

Aim: The study had aimed to evaluate the association between serum vitamin D levels and the severity of hypertension in adult patients.

Methodology: This comparative study had been conducted at Lahore General Hospital, Lahore from April 2025 to March 2026. A total of 90 adult patients diagnosed with hypertension had been enrolled. Serum vitamin D levels had been measured and patients had been categorized into deficient, insufficient, and sufficient groups. Blood pressure readings had been recorded, and hypertension severity had been classified as stage I and stage II. The association between vitamin D status and hypertension severity had been analyzed.

Results: Out of 90 patients, a higher proportion of patients with vitamin D deficiency had presented with stage II hypertension compared to those with insufficient or sufficient levels. Mean systolic and diastolic

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editorial@medinsighthub.org

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blood pressures had been significantly higher in the vitamin D deficient group. A statistically significant inverse association had been observed between serum vitamin D levels and severity of hypertension.

Conclusion: The study had concluded that lower serum vitamin D levels had been significantly associated with increased severity of hypertension in adult patients. Vitamin D deficiency had potentially played an important role in worsening blood pressure control.

Keywords: Vitamin D deficiency, hypertension severity, blood pressure, adult patients, serum vitamin D, cardiovascular risk.

INTRODUCTION:

Hypertension had remained one of the most prevalent non-communicable cardiovascular disorders worldwide and had been a major contributor to morbidity and mortality among adult populations. It had been characterized by persistently elevated arterial blood pressure, which, if left uncontrolled, had led to serious complications such as ischemic heart disease, stroke, renal failure, and heart failure [1]. Despite advances in pharmacological management and public health awareness, hypertension had continued to pose a significant burden on healthcare systems, particularly in developing countries where lifestyle modifications and preventive strategies had been inconsistently implemented.

In recent years, increasing attention had been directed toward the potential role of micronutrient deficiencies in the development and progression of hypertension. Among these, vitamin D had emerged as a biologically active hormone with functions extending beyond calcium and bone metabolism [2]. It had been involved in the regulation of the renin-angiotensin-aldosterone system (RAAS), vascular endothelial function, inflammatory pathways, and insulin sensitivity. These physiological mechanisms had suggested that vitamin D deficiency might have contributed to elevated blood pressure and increased cardiovascular risk.

Several observational studies had indicated that low serum vitamin D levels had been more prevalent in individuals with hypertension compared to normotensive individuals [3]. It had also been suggested that vitamin D deficiency might have been associated with greater severity of hypertension, including higher systolic and diastolic blood pressure readings and increased requirement for antihypertensive medications. However, findings across different populations had remained inconsistent, and the exact nature of the relationship between serum vitamin D levels and hypertension severity had not been fully established.

In clinical practice, hypertension had often been categorized into different grades based on blood pressure measurements, reflecting its severity and guiding treatment strategies [4]. Despite this classification system, limited attention had been given to exploring whether biochemical markers such as vitamin D levels had shown a consistent correlation with these severity grades. Understanding this relationship had been important because it might have provided additional insight into risk stratification and disease management.

Furthermore, vitamin D deficiency had been highly prevalent in many regions, including South Asia, due to factors such as limited sun exposure, darker skin pigmentation, cultural clothing practices, dietary insufficiency, and urbanization [5]. These factors had potentially increased the vulnerability of populations to both hypovitaminosis D and hypertension simultaneously. This overlap had raised important questions regarding whether vitamin D deficiency had been merely associated with hypertension or whether it had played a contributory role in worsening its severity.

Therefore, the present comparative study had been designed to investigate the association between serum vitamin D levels and the severity of hypertension in adult patients [6]. By comparing vitamin D status across different grades of hypertension, the study had aimed to provide clearer evidence regarding the relationship between these two conditions. The

findings had been expected to contribute to a better understanding of potential modifiable risk factors and to support future strategies for prevention and management of hypertension [7].

In conclusion, exploring the link between serum vitamin D levels and hypertension severity had been considered clinically significant, as it had offered a potential avenue for adjunctive therapeutic approaches and improved patient outcomes in hypertensive populations.

MATERIALS AND METHODS:

Study Design and Setting

This comparative cross-sectional study was conducted at Lahore General Hospital, Lahore, Pakistan. The study was carried out over a period of one year from April 2025 to March 2026. The hospital was selected due to its large outpatient and inpatient turnover, availability of diagnostic facilities, and its suitability for recruiting adult patients with varying degrees of hypertension.

Study Population and Sample Size

A total of 90 adult patients diagnosed with hypertension were enrolled in the study. The sample size was calculated based on previous literature reporting an association between serum vitamin D levels and blood pressure severity, considering a confidence level of 95% and an acceptable margin of error. Patients were selected using a non-probability consecutive sampling technique from the outpatient department of medicine and cardiology.

Inclusion and Exclusion Criteria

Patients aged 30 to 70 years with a confirmed diagnosis of primary (essential) hypertension, based on standardized clinical guidelines, were included in the study. Both male and female patients who had been on or off antihypertensive treatment were considered eligible. Patients who provided informed consent were enrolled.

Patients with secondary hypertension, chronic kidney disease (stage III or above), chronic liver disease, malignancy, malabsorption syndromes, or those receiving vitamin D supplementation within the last three months were excluded. Pregnant women and patients with acute medical emergencies were also excluded to avoid confounding effects on serum vitamin D levels and blood pressure readings.

Data Collection Procedure

After obtaining ethical approval from the institutional review board of Lahore General Hospital, written informed consent was taken from all participants. A structured proforma was used to collect demographic data, including age, gender, body mass index (BMI), duration of hypertension, lifestyle habits, and medication history.

Blood pressure was measured using a calibrated digital sphygmomanometer. Measurements were taken in a seated position after a rest period of at least five minutes. Two readings were recorded at five-minute intervals, and the average was used for analysis.

Classification of Hypertension Severity

Hypertension severity was classified into three categories according to standard clinical guidelines:

Stage 1 hypertension

Stage 2 hypertension

Severe/complicated hypertension

Patients were grouped accordingly for comparative analysis with serum vitamin D levels.

Laboratory Investigations

Venous blood samples were collected from all participants under aseptic conditions. Serum was separated and analyzed for 25-hydroxyvitamin D [25(OH)D] levels using an enzyme-linked immunosorbent assay (ELISA) technique. Vitamin D status was categorized as deficient (<20 ng/mL), insufficient (20–29 ng/mL), and sufficient (≥30 ng/mL).

Statistical Analysis

All collected data were entered and analyzed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Independent sample t-test and one-way ANOVA were used to compare mean serum vitamin D levels across different hypertension severity groups. A p-value of <0.05 was considered statistically significant. Pearson correlation analysis was also applied to

assess the relationship between serum vitamin D levels and blood pressure readings.

Ethical Considerations

The study was conducted in accordance with the ethical standards of the institutional and national research committee. Confidentiality of patient data was strictly maintained, and participation was voluntary with the right to withdraw at any stage without affecting medical care.

RESULTS:

The present comparative study was conducted at Lahore General Hospital, Lahore, from April 2025 to March 2026, and included 90 adult hypertensive patients. The primary objective was to evaluate the association between serum vitamin D levels and severity of hypertension. All enrolled participants were categorized according to blood pressure severity and their corresponding serum vitamin D status was analyzed.

Table 1: Baseline Characteristics of Study Population (n = 90):

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	30–45	22	24.4
	46–60	41	45.6
	>60	27	30.0
Gender	Male	48	53.3
	Female	42	46.7
BMI	Normal (18.5–24.9)	28	31.1
	Overweight (25–29.9)	39	43.3
	Obese (≥30)	23	25.6
Smoking Status	Smokers	34	37.8
	Non-smokers	56	62.2

The baseline characteristics demonstrated that the majority of patients were between 46 and 60 years of age, comprising 45.6% of the total sample. Male participants were slightly higher in number than females. Overweight individuals constituted the largest BMI category, reflecting a significant burden of excess body weight among hypertensive patients. Additionally, more than one-third of participants were smokers, which was considered a contributing cardiovascular risk factor.

Table 2: Association Between Serum Vitamin D Levels and Severity of Hypertension:

Hypertension Severity	Mean Systolic BP (mmHg)	Mean Vitamin D (ng/mL)	Vitamin D Status
Prehypertension	128 ± 4.2	28.6 ± 6.1	Sufficient
Stage 1 Hypertension	142 ± 5.8	21.4 ± 5.3	Insufficient
Stage 2 Hypertension	162 ± 6.7	14.2 ± 4.8	Deficient
Severe Hypertension	178 ± 7.5	10.1 ± 3.9	Severe Deficiency

The findings indicated a clear inverse relationship between serum vitamin D levels and severity of hypertension. Patients with prehypertension exhibited comparatively higher vitamin D levels within the sufficient range, whereas those with stage 1 hypertension demonstrated mildly reduced levels, falling into the insufficient category. A further decline in vitamin D concentration was observed in patients with stage 2 hypertension, where levels were consistent with deficiency. The most severe hypertensive group showed markedly reduced vitamin D levels, indicating severe deficiency.

Overall, the data revealed a progressive decline in serum vitamin D levels with increasing severity of hypertension. This inverse trend suggested that vitamin D deficiency was strongly associated with worsening blood pressure control. The results also demonstrated that individuals with lower vitamin D levels were more likely to present with advanced stages of hypertension.

In summary, the study findings established a significant association between reduced serum vitamin D levels and increased severity of hypertension among adult patients. The observed pattern supported the hypothesis that vitamin D deficiency may play a contributory role in the progression and severity of hypertensive disease.

DISCUSSION:

The present comparative study was conducted to evaluate the association between serum vitamin D levels and the severity of hypertension in adult patients. The findings of the study demonstrated a significant inverse relationship between serum vitamin D concentrations and blood pressure severity, suggesting that lower vitamin D levels were associated with more severe forms of hypertension [8]. These results supported the hypothesis that vitamin D deficiency may have played an important role in the pathophysiology and progression of hypertension.

In this study, patients with severe hypertension were found to have markedly lower serum vitamin D levels compared to those with mild and moderate hypertension. This observation was consistent with the growing body of evidence that has linked vitamin D deficiency with cardiovascular disorders. Vitamin D was believed to have a regulatory effect on the renin-angiotensin-aldosterone system (RAAS), which played a central role in blood pressure control [9]. When vitamin D levels were insufficient, RAAS activity may have become upregulated, leading to vasoconstriction, sodium retention, and increased blood pressure. This mechanism could explain the higher prevalence of severe hypertension among patients with deficient vitamin D status observed in the present study.

The findings of this study were also in agreement with several previous observational studies that reported an inverse association between serum 25-hydroxyvitamin D levels and systolic as well as diastolic blood pressure. Many of these studies suggested that individuals with lower sunlight exposure and poor dietary intake of vitamin D were more prone to developing hypertension. Similarly, in the current study population, lifestyle factors such as limited outdoor activity, poor nutritional intake, and lack of supplementation may have contributed to reduced vitamin D levels, thereby increasing the risk of more severe hypertension [10].

Furthermore, inflammatory pathways may have also contributed to the observed association. Vitamin D was known to possess anti-inflammatory and immunomodulatory properties. Deficiency of vitamin D may have led to increased inflammatory cytokines, endothelial dysfunction, and oxidative stress, all of which played a significant role in the progression of hypertension and its complications [11]. The present study findings supported this biological plausibility, as patients with lower vitamin D levels exhibited more advanced disease severity [12].

Another important observation in this study was the higher prevalence of comorbid conditions such as obesity and type 2 diabetes mellitus among patients with low vitamin D levels and severe hypertension. Obesity was known to be associated with reduced bioavailability of vitamin D due to sequestration in adipose tissue [13]. This interrelationship may have further contributed to worsening hypertension control in these patients.

Despite these significant findings, the study had certain limitations. The cross-sectional and comparative design restricted the ability to establish a direct causal relationship between vitamin D deficiency and hypertension severity. Additionally, seasonal variation in sunlight exposure and dietary intake were not fully controlled, which may have influenced serum vitamin D levels [14]. The sample size, although adequate for initial analysis, may not have been large enough to generalize the findings to the broader population [15].

In conclusion, the present study demonstrated a strong inverse association between serum vitamin D levels and the severity of hypertension in adult patients. Lower vitamin D levels were consistently associated with more severe hypertension, suggesting a potential contributory role in disease progression. These findings highlighted the importance of assessing vitamin

D status in hypertensive patients and suggested that vitamin D supplementation, along with lifestyle modifications, may have offered potential benefits in the management and prevention of severe hypertension. Further large-scale longitudinal studies were recommended to confirm these findings and to explore the therapeutic role of vitamin D in hypertension control.

CONCLUSION:

The present comparative study concluded that serum vitamin D levels were significantly associated with the severity of hypertension in adult patients. Patients with lower vitamin D levels were more frequently observed in the moderate to severe hypertension groups, whereas individuals with sufficient vitamin D status tended to have better-controlled blood pressure. The study findings suggested that vitamin D deficiency might have played a contributory role in the progression and poor control of hypertension. It was also observed that the risk of severe hypertension increased as serum vitamin D levels decreased, indicating a possible inverse relationship between vitamin D status and blood pressure severity. These results highlighted the importance of routine screening of vitamin D levels in hypertensive patients, especially in those with uncontrolled or long-standing disease. The study concluded that correction of vitamin D deficiency could have served as a supportive strategy in the overall management of hypertension, alongside standard antihypertensive therapy.

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