Annals OF Advanced Medical Sciences

Original Research Article

STUDY OF VITAMIN D STATUS IN HYPERTENSION

Nikhil T K[1], Adarsh Mukhtedar[2], Bindhumathi P L[3]

1. MBBS, MD General Medicine, Postgraduate, Department of General Medicine, Sapthagiri Institute of Medical Sciences & Research Centre, Bengaluru, Karnataka, India
2. MBBS, MD General Medicine, Postgraduate, Department of General Medicine, Sapthagiri Institute of Medical Sciences & Research Centre, Bengaluru, Karnataka, India
3. Professor, Department of General Medicine, Sapthagiri Institute of Medical Sciences & Research Centre, Bengaluru, Karnataka, India

Correspondence: Dr Nikhil T K

Received: 10 Aug 2026 | Accepted: 18 Aug 2026 | Published: 24 Aug 2026

Abstract

Background: Hypertension is a major cardiovascular risk factor associated with increased morbidity and mortality. Vitamin D has important extra-skeletal roles, including regulation of vascular function and blood pressure homeostasis. This study evaluated the association between vitamin D status and systemic hypertension.
Materials and Methods: A hospital-based case-control study was conducted, over 6 months. The study included 100 participants comprising 50 newly diagnosed hypertensive patients (cases) and 50 normotensive controls. Serum vitamin D levels were measured and compared between both groups.
Results: The mean vitamin D level was significantly lower among hypertensive patients compared with controls (20.84 ± 6.48 ng/mL vs 40.14 ± 15.27 ng/mL; p=0.001). A significant association was observed between reduced vitamin D levels and systemic hypertension.
Conclusion: Hypertensive patients demonstrated significantly lower vitamin D levels compared with normotensive individuals. Vitamin D deficiency may be associated with hypertension and may serve as an additional cardiovascular risk marker.
Keywords: Vitamin D, Hypertension, 25-hydroxyvitamin D, Blood pressure, Case-control study.

Introduction

Hypertension is one of the most prevalent non-communicable diseases worldwide and remains a major public health concern due to its strong association with cardiovascular, cerebrovascular, and renal complications[1]. It is a leading modifiable risk factor for morbidity and mortality, and early diagnosis along with appropriate management can significantly reduce the burden of hypertension-related complications. Identification of additional modifiable factors associated with hypertension remains an important area of research[1].

Vitamin D is a fat-soluble secosteroid hormone that plays an essential role in calcium and phosphate metabolism and maintenance of skeletal health. However, increasing evidence suggests that vitamin D has important extra-skeletal functions mediated through vitamin D receptors expressed in various tissues, including vascular smooth muscle cells, endothelial cells, myocardium, and immune cells. These findings have generated interest regarding the possible role of vitamin D in cardiovascular regulation and blood pressure homeostasis [1,2].Vitamin D deficiency is a common global health problem and has been associated with multiple chronic disorders, including cardiovascular diseases, metabolic syndrome, diabetes mellitus, and hypertension. Observational studies have demonstrated an inverse relationship between serum 25-hydroxyvitamin D [25(OH)D] concentration and blood pressure levels. Forman et al. reported that lower plasma 25(OH)D concentrations were associated with an increased risk of incident hypertension, suggesting a possible relationship between vitamin D deficiency and development of elevated blood pressure [1]. Similarly, systematic reviews have highlighted an association between poor vitamin D status and increased prevalence of arterial hypertension and cardiometabolic disorders [2,3].Several mechanisms have been proposed to explain the relationship between vitamin D

deficiency and hypertension. Vitamin D may regulate blood pressure through suppression of the renin–angiotensin–aldosterone system, modulation of vascular inflammation, improvement of endothelial function, and regulation of vascular smooth muscle activity. Experimental evidence has demonstrated that 1,25-dihydroxyvitamin D3 acts as a negative endocrine regulator of renin expression, suggesting a potential protective role of vitamin D against hypertension development [4]. Furthermore, vitamin D status has been associated with arterial stiffness and vascular dysfunction, which are important contributors to increased vascular resistance and cardiovascular risk [5].Although epidemiological studies have consistently suggested an association between vitamin D deficiency and hypertension, the nature of this relationship remains uncertain. Some studies suggest that vitamin D deficiency may contribute directly to hypertension, whereas others propose that low vitamin D levels may represent a marker of poor health status or associated cardiovascular risk. Systematic reviews and Mendelian randomization studies have attempted to clarify this relationship; however, evidence regarding a causal association between vitamin D status and hypertension remains inconclusive [6,7].

Clinical trials assessing the effect of vitamin D supplementation on blood pressure have also produced variable results. While some studies have reported modest improvements in blood pressure parameters following supplementation, systematic reviews and meta-analyses have generally shown limited or inconsistent effects, particularly among individuals without severe vitamin D deficiency. These findings indicate that vitamin D may have an important association with hypertension risk, although its role as a therapeutic intervention requires further investigation [8,9].Previous studies evaluating vitamin D status among hypertensive and normotensive populations have reported significant differences in serum vitamin D concentrations. However, variations in geographical location, sunlight exposure, dietary habits, lifestyle factors, genetic background, and population characteristics may influence vitamin D levels and their association with hypertension. Therefore, evaluation of vitamin D status in different populations remains important to further understand this relationship [2,10].

The present case-control study was undertaken to assess vitamin D status among patients with systemic hypertension and compare serum vitamin D levels with age- and sex-matched normotensive controls.

Methodology:

The present study was conducted as a hospital-based case-control study in the Department of General Medicine . The study was carried out over a period of 6 months. The study aimed to compare serum vitamin D levels among patients with systemic hypertension and normotensive controls to evaluate the association between vitamin D status and hypertension.

Study Population

The study included newly diagnosed patients with systemic hypertension attending the hypertension outpatient department and patients admitted to the medical wards of SIMS & RC, Bengaluru. A group of normotensive individuals was included as controls for comparison. All eligible participants were enrolled after obtaining written informed consent.

Selection Criteria

Definition of Systemic Hypertension

Systemic hypertension was defined according to the JNC 8 criteria. Patients with:

- Systolic blood pressure ≥140 mmHg and/or
- Diastolic blood pressure ≥90 mmHg

were considered hypertensive.

Inclusion Criteria

Patients fulfilling the following criteria were included in the study:

- Newly diagnosed cases of systemic hypertension.
- Patients attending the hypertension outpatient department or admitted in the medical wards of SIMS & RC, Bengaluru.
- Patients willing to participate in the study after providing written informed consent.

Exclusion Criteria

Patients with the following conditions were excluded:

- Secondary hypertension.
- Patients already receiving vitamin D supplementation.
- Patients already receiving calcium supplementation.
- Patients unwilling to participate in the study.
- Patients diagnosed with chronic kidney disease.
- Patients diagnosed with chronic liver disease.

Data Collection Method

Data were collected using a pre-designed proforma after obtaining informed consent from all participants. Demographic details, clinical history, and relevant medical information were recorded. Patients with systemic hypertension were evaluated

from the medicine wards and hypertension outpatient department of SIMS & RC, Bengaluru.

Blood pressure measurements were recorded, and serum vitamin D levels were assessed in both hypertensive patients and normotensive controls. The collected data were analyzed to compare vitamin D status between the two groups and evaluate its association with systemic hypertension.

Results:

The present case-control study included 100 participants, comprising 50 hypertensive patients (cases) and 50 normotensive controls. The mean age was comparable between cases (49.2 ± 10.4 years) and controls (48.1 ± 9.8 years) (p=0.58). Gender distribution and BMI were also similar between both groups (Table 1).The mean systolic blood pressure (154.8 ± 12.6 vs 122.4 ± 9.8 mmHg), diastolic blood pressure (95.2 ± 8.4 vs 78.6 ± 7.2 mmHg), and pulse pressure (59.6 ± 11.8 vs 43.8 ± 8.9 mmHg) were significantly higher among cases compared with controls (p<0.001) (Table 2, Figure 1).Serum vitamin D levels were significantly lower among hypertensive patients compared with normotensive controls. The mean vitamin D level was 20.84 ± 6.48 ng/mL in cases and 40.14 ± 15.27 ng/mL in controls (p=0.001) (Table 3).Vitamin D deficiency (<20 ng/mL) was observed in 56.0% of cases compared with 18.0% of controls, whereas vitamin D sufficiency (≥30 ng/mL) was higher among controls (54.0%) compared with cases (10.0%) (p<0.001) (Table 4, Figure 2).Among hypertensive patients, vitamin D levels showed a significant negative correlation with systolic blood pressure (r=-0.42, p=0.002), diastolic blood pressure (r=-0.36, p=0.010), and mean arterial pressure (r=-0.40, p=0.004) (Table 5, Figure 3).Vitamin D deficiency was significantly associated with hypertension, with deficient individuals having higher odds of hypertension compared with non-deficient individuals (OR: 5.79, 95% CI: 2.24–14.94; p<0.001) (Table 6).

Table 1. Demographic Characteristics of Study Participants (N=100)

Parameter	Cases (n=50)	Controls (n=50)	p-value
Age (years), Mean ± SD	49.2 ± 10.4	48.1 ± 9.8	0.58
Male, n (%)	30 (60.0%)	29 (58.0%)	0.84
Female, n (%)	20 (40.0%)	21 (42.0%)	
BMI (kg/m²), Mean ± SD	26.1 ± 3.4	24.8 ± 3.1	0.05

Independent sample t-test and Chi-square test

Table 2. Clinical Characteristics of Cases and Controls

Clinical Parameter	Cases (n=50)	Controls (n=50)	p-value
Systolic BP (mmHg), Mean ± SD	154.8 ± 12.6	122.4 ± 9.8	<0.001
Diastolic BP (mmHg), Mean ± SD	95.2 ± 8.4	78.6 ± 7.2	<0.001
Pulse Pressure (mmHg), Mean ± SD	59.6 ± 11.8	43.8 ± 8.9	<0.001

Independent sample t-test

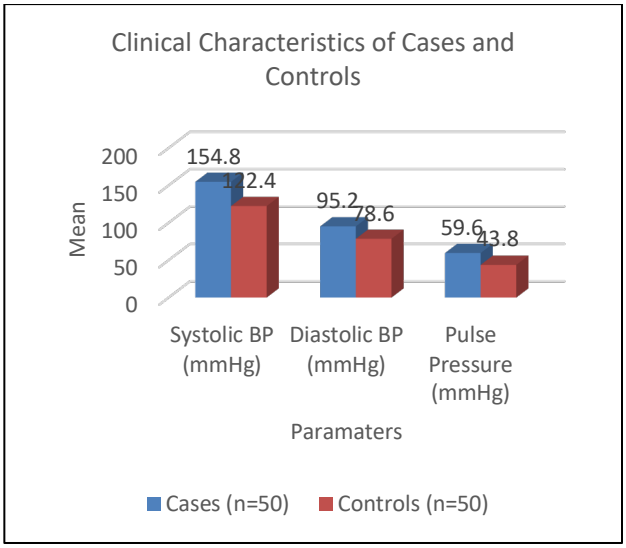

Figure 1. Clinical Characteristics of Cases and Controls

Table 3. Comparison of Mean Vitamin D Levels Between Cases and Controls

Group	Number (n)	Mean Vitamin D Level (ng/mL)	SD	p-value
Cases	50	20.84	6.48	
Controls	50	40.14	15.27	0.001

Unpaired (independent) t-test

Table 4. Distribution of Vitamin D Status Among Cases and Controls

Vitamin D Status	Cases (n=50)	Controls (n=50)	p-value
Deficient (<20 ng/mL)	28 (56.0%)	9 (18.0%)	
Insufficient (20–29 ng/mL)	17 (34.0%)	14 (28.0%)	
Sufficient (≥30 ng/mL)	5 (10.0%)	27 (54.0%)	<0.001

Chi-square test

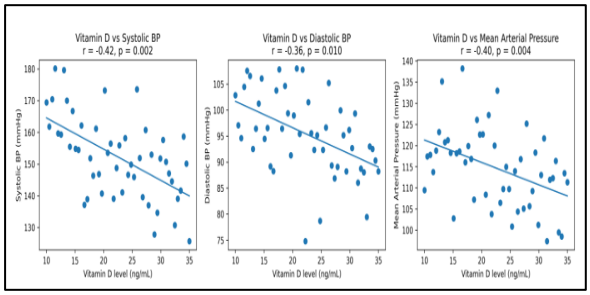

Figure 2. Distribution of Vitamin D Status Among Cases and Controls

Table 5. Correlation Between Vitamin D Level and Blood Pressure Parameters Among Hypertensive Patients (n=50)

Parameter	Correlation coefficient (r)	p-value
Vitamin D vs Systolic BP	-0.42	0.002
Vitamin D vs Diastolic BP	-0.36	0.010
Vitamin D vs Mean Arterial Pressure	-0.40	0.004

Pearson correlation test

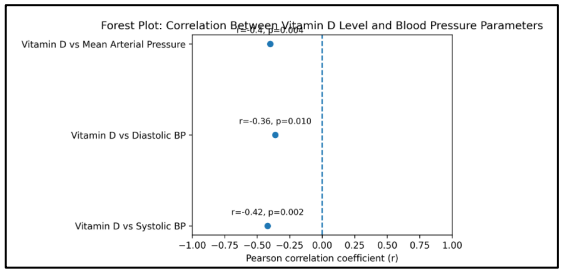

Figure 3. Correlation Between Vitamin D Level and Blood Pressure Parameters Among Hypertensive Patients (n=50)

Table 6. Association Between Vitamin D Deficiency and Hypertension Status

Vitamin D Status	Cases (n=50)	Controls (n=50)	Odds Ratio (95% CI)	p-value
Deficient	28 (56.0%)	9 (18.0%)	5.79 (2.24 – 14.94)	<0.001
Non-deficient	22 (44.0%)	41 (82.0%)	-	

Discussion

Hypertension is a major global health concern and an important modifiable risk factor for cardiovascular morbidity and mortality. In the present study, 50 newly diagnosed hypertensive patients were compared with 50 normotensive controls to evaluate the association between vitamin D status and hypertension. Whelton et al. [11] emphasized the importance of early detection, risk-factor modification, and comprehensive management of hypertension to reduce cardiovascular complications. Similarly, Unger et al. [12] highlighted the need for evaluation of associated metabolic and lifestyle-related factors in hypertensive patients.

The present study demonstrated significantly lower serum vitamin D levels among hypertensive patients compared with normotensive controls. The mean vitamin D level was 20.84 ± 6.48 ng/mL in cases and 40.14 ± 15.27 ng/mL in controls, with a statistically significant difference (p=0.001)Forman et al. [1] reported that lower plasma 25-hydroxyvitamin D levels were associated with an increased risk of incident hypertension, suggesting a possible role of vitamin D deficiency in blood pressure regulation. Pilz et al. [2], in a systematic review, also reported an inverse association between vitamin D status and arterial hypertension, indicating that individuals with lower vitamin D levels had a higher prevalence of hypertension.These findings are consistent with the present study, where hypertensive patients showed significantly reduced vitamin D concentrations compared with normotensive individuals.The relationship between vitamin D deficiency and hypertension may involve regulation of the renin–angiotensin system, endothelial function, and vascular homeostasis. Fountain et al. [13] described the central role of the renin–angiotensin system in blood pressure regulation

through modulation of vasoconstriction and sodium balance.Li et al. [4] demonstrated that 1,25-dihydroxyvitamin D3 acts as a negative regulator of renin expression and suppresses renin–angiotensin system activity. Thus, vitamin D deficiency may contribute to increased renin activity and elevation of blood pressure.The lower vitamin D levels observed among hypertensive patients in the present study support the possible involvement of vitamin D in blood pressure regulation through these mechanisms.Vitamin D has important extra-skeletal functions beyond calcium and bone metabolism. Charoenngam et al. [14] highlighted the role of vitamin D in cardiovascular, immune, and metabolic functions through vitamin D receptors present in multiple tissues.Al Mheid et al. [5] reported that vitamin D status was associated with arterial stiffness and vascular dysfunction, suggesting that vitamin D deficiency may contribute to increased cardiovascular risk through adverse vascular effects.In agreement with these findings, the present study demonstrated significantly lower vitamin D levels among hypertensive patients, supporting its potential role as a cardiovascular risk marker.Although observational studies suggest an association between vitamin D deficiency and hypertension, the effect of vitamin D supplementation on blood pressure remains uncertain.Fadilla et al. [15], in a systematic review and meta-analysis, reported that vitamin D supplementation significantly increased serum 25(OH)D concentrations; however, its effect on blood pressure reduction was inconsistent. These findings indicate that vitamin D deficiency may be associated with hypertension, but supplementation alone may not consistently improve blood pressure control.

The present study highlights the association between vitamin D deficiency and systemic hypertension. Hypertensive patients had significantly lower vitamin D levels compared with controls (20.84 ± 6.48 ng/mL vs 40.14 ± 15.27 ng/mL; p=0.001). Assessment of vitamin D status may provide additional information regarding cardiovascular risk profile among hypertensive patients. However, further prospective studies are required to establish causality and determine the therapeutic role of vitamin D supplementation in hypertension.

Conclusion

The present study demonstrated significantly lower serum vitamin D levels among hypertensive patients compared with normotensive controls (20.84 ± 6.48 ng/mL vs 40.14 ± 15.27 ng/mL; p=0.001).Vitamin D deficiency was found to be significantly associated with systemic hypertension, suggesting its potential role as a cardiovascular risk marker. Further large-scale prospective studies are required to establish the causal relationship and therapeutic significance of vitamin D supplementation in hypertension.

Limitations

The study was conducted with a relatively limited sample size at a single center, which may restrict the generalizability of the findings. The case-control design identifies association but cannot establish a definite causal relationship between vitamin D deficiency and hypertension.

Ethical approval

Ethical approval for this study was obtained from the Institutional Ethics Committee prior to the commencement of the study. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and applicable institutional guidelines.

Informed Consent

Written informed consent was obtained from all participants prior to their enrolment in the study.

Funding Statement.

The authors received no financial support for the research, authorship, and/or publication of this article.

Conflict of Interest Declaration

The authors declare no conflict of interest.Data Availability Statement. All data generated or analysed during this study are available from the corresponding author upon reasonable request..

References

1. Forman JP, Giovannucci E, Holmes MD, Bischoff-Ferrari HA, Tworoger SS, Willett WC, et al. Plasma 25-hydroxyvitamin D levels and risk of incident hypertension. Hypertension. 2007;49(5):1063-1069.
2. Pilz S, Tomaschitz A, Ritz E, Pieber TR. Vitamin D status and arterial hypertension: a systematic review. Nat Rev Cardiol. 2009;6(10):621-630.
3. Parker J, Hashmi O, Dutton D, Mavrodaris A, Stranges S, Kandala NB, et al. Levels of vitamin D and cardiometabolic disorders: systematic review and meta-analysis. Maturitas. 2010;65(3):225-236.

4. Li YC, Kong J, Wei M, Chen ZF, Liu SQ, Cao LP. 1,25-Dihydroxyvitamin D3 is a negative endocrine regulator of the renin-angiotensin system. J Clin Invest. 2002;110(2):229-238.
5. Al Mheid I, Patel R, Murrow J, Morris A, Rahman A, Fike L, et al. Vitamin D status is associated with arterial stiffness and vascular dysfunction in healthy adults. J Am Coll Cardiol. 2011;58(2):186-192.
6. Kunutsor SK, Whitehouse MR, Blom AW, Laukkanen JA. Low vitamin D status and the risk of hypertension: a systematic review and meta-analysis of prospective studies. Hypertension. 2013;62(5):1024-1032.
7. Vimaleswaran KS, Cavadino A, Berry DJ, Jorde R, Dieffenbach AK, Lu C, et al. Association of vitamin D status with arterial blood pressure and hypertension risk: a Mendelian randomisation study. Lancet Diabetes Endocrinol. 2014;2(9):719-729.
8. Witham MD, Nadir MA, Struthers AD. Effect of vitamin D on blood pressure: a systematic review and meta-analysis. J Hypertens. 2009;27(10):1948-1954.
9. Beveridge LA, Struthers AD, Khan F, Jorde R, Scragg R, Macdonald HM, et al. Effect of vitamin D supplementation on blood pressure: a systematic review and meta-analysis incorporating individual patient data. JAMA Intern Med. 2015;175(5):745-754.
10. Vaidya A, Forman JP. Vitamin D and hypertension: current evidence and future directions. Hypertension. 2010;56(5):774-779.
11. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Himmelfarb CD, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: executive summary. J Am Coll Cardiol. 2018;71:2199-2269.
12. Unger T, Borghi C, Charchar F, Khan NA, Poulter NR, Prabhakaran D, et al. 2020 International Society of Hypertension global hypertension practice guidelines. Hypertension. 2020;75:1334-1357.
13. Fountain JH, Kaur J, Lappin SL. Physiology, renin angiotensin system. Treasure Island (FL): StatPearls Publishing; 2023.
14. Charoenngam N, Shirvani A, Holick MF. Vitamin D for skeletal and nonskeletal health: what we should know. J Clin Orthop Trauma. 2019;10:1082-1093.
15. Fadilla C, Yogiswara N, Adriani M. Effects of vitamin D supplementation on 25(OH)D concentrations and blood pressure in the elderly: a systematic review and meta-analysis. F1000Res. 2020;9:633.