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A Study on Association Between Vitamin D Status and Primary Hypertension

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Abstract:

- ***Aim:***
  To study association between vit D levels among Hypertension patients Attending a tertiary care hospital.

- ***Background and Objectives :***
  Previous studies have suggested that individuals with low vitamin D levels are more likely to develop hypertension. Vitamin D deficiency may increase blood pressure through activation of the renin–angiotensin–aldosterone system, impaired vasodilation, increased vascular stiffness, and altered calcium metabolism. However, evidence regarding this association remains inconsistent, especially in the Indian population where vitamin D deficiency is common despite adequate sunlight exposure.

- ***Materials and Methods***
  A cross-sectional study was conducted in the Department of General Medicine, Katuri Medical College and Hospital, Guntur, over a period of two years. A total of 100 adults with primary hypertension were included. Patients above 18 years who provided informed consent were enrolled, while those with chronic kidney disease, chronic liver disease, or on vitamin D/calcium supplements were excluded. Blood pressure was recorded according to JNC-8 criteria, and serum vitamin D levels were measured. The collected data were statistically analyzed to assess the association between vitamin D levels and blood pressure.

- ***Results***
  The study included 100 patients diagnosed with primary hypertension. Most participants belonged to the middle-aged group, with a mean age of approximately 46 years. Female participants slightly outnumbered males.

  The average systolic blood pressure was around 156 mmHg, while the mean diastolic blood pressure was nearly 90 mmHg. The mean serum vitamin D level was found to be in the insufficient range.

- ***A Large Proportion of Patients Showed Inadequate Vitamin D Status:***

✓ **10% had vitamin D deficiency**
✓ **82% had vitamin D insufficiency**
✓ **Only 8% had sufficient vitamin D levels**

Analysis demonstrated an inverse association between serum vitamin D concentration and blood pressure values. Patients with lower vitamin D levels tended to have higher systolic and diastolic blood pressure readings.

- ***Conclusion***
  The present study revealed a high prevalence of vitamin D insufficiency among individuals with primary hypertension. Lower vitamin D levels were associated with higher blood pressure measurements, suggesting a possible role of vitamin D deficiency in the pathogenesis of hypertension. These findings indicate that assessment of vitamin D status may be useful in

hypertensive patients. Further large-scale prospective studies are required to determine whether vitamin D supplementation can contribute to better blood pressure control.

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I. INTRODUCTION

Hypertension is regarded as a primary contributor to global disability-adjusted life years. Hypertension has numerous etiological factors, including age, ethnicity, familial predisposition, obesity, inactive lifestyle, use of tobacco, extreme salt consumption, stress, and heavy alcohol intake.[1]

Hypertension is among the most changeable predisposing factors for premature mortality globally. The disease is predominantly asymptomatic, however it is detectable and treatable; if neglected, it may result in enduring damage to the heart, blood vessels, and other organs.[2]

Hypertension is classified into two categories: primary and secondary. Primary hypertension has an unknown etiology and arises when the equilibrium between arterial vasoconstriction and vasodilation is disrupted, resulting in prolonged arterial contraction. In secondary hypertension, blood pressure elevation is attributable to an identifiable and treatable underlying condition.[3]Secondary hypertension may arise from various conditions, such as kidney parenchymal disease, renal artery narrowing, primary aldosteronism, pheochromocytoma, and Cushing's syndrome.[4]

Vitamin D insufficiency has historically been linked to inadequate bone growth and the Emergence of rickets in children, osteoporosis in adults. Lately, more focus has been Directed towards the involvement of vitamin D in additional domains beyond those Traditionally recognized.[8] Recent research in the last 20 years indicates that vitamin D Deficiency be a contributing factor for various chronic diseases, including hypertension, Diabetes mellitus, dyslipidemia, cardiovascular disease, some malignancies, autoimmune 1 Diseases, and tuberculosis. The socioeconomic impact of the above mentioned chronic Illnesses connected with vitamin D deficiency is substantial.[9]

Vitamin D significantly influences the pathogenesis of arterial hypertension. Vitamin D Influences the renin-angiotensin-aldosterone system (RAAS). Elevated parathormone (PTH) levels, indicative of vitamin D insufficiency, may also elevate blood pressure. Research indicates a favourable relationship between PTH levels and blood pressure. [10]

Epidemiological cross-sectional research have consistently demonstrated a correlation Between hypertension and deficiency of vitamin D, as indicated by blood concentrations Of 25-hydroxyvitamin D (25OHD) in nanomoles per litre. Recent meta-analyses of Prospective studies have also confirmed the persistence of this association over time.[11]

➢ *Aims and Objectives*

- *Aim:*

To study association between vit D levels among Hypertension patients Attending a tertiary care hospital.

- *Objectives:*

✓ To determine the plasma vit-D concentrations in Primary hypertensive patients.
✓ To assess if low plasma vit- D concentrations are association with primary hypertension.

II. MATERIALS AND METHODS

➢ STUDY DESIGN: Cross-sectional study
➢ STUDY PERIOD: 2 years
➢ STUDY PLACE: Department of General Medicine, Katuri medical college and hospital, Guntur.
➢ SAMPLE SIZE: 100 patients

- *Inclusion Criteria*

✓ All patients over 18 years age presenting with hypertension.
✓ Individuals who were ready to give written, informed consent for the research.

- *Exclusion Criteria*

✓ Patients currently consuming calcium supplements
✓ Patients currently using Vitamin D supplements
✓ Patients refusal to take part in research
✓ Individuals having a chronic kidney illness diagnosis
✓ Individual's diagnosis with chronic liver disease.

➢ *Data Collection:*

- *Systemic Hypertension:*

Definition of Hypertension According To JNC 8

✓ Systolic blood pressure more than or equal to 140
✓ Diastolic blood pressure more than or equal to 90

III. OBSERVATIONS AND RESULTS

One hundred patients with primary hypertension from General Medicine at Katuri Medical College and Hospital, Guntur, participated in this cross-sectional department study.

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The demographic attributes, blood pressure measurements, and serum vitamin D concentrations of the Research participants were examined.

➢ *The Age Demographics of Study Population*

The patients' ages varied from 30 to 65 years. The average age range of the study group was 45.63 ± 8.77 years.

The predominant cohort of patients was aged 40–50 years, succeeded by those aged 50–60 years.

Table 1 Age Distribution of Research Subjects

Age	Frequency	percentage
21-30 years	3	3%
31-40 years	21	21%
41-50 years	55	55%
51-60 years	21	21%
Total	100	100%
Mean±S.D	45.63 ± 8.77	

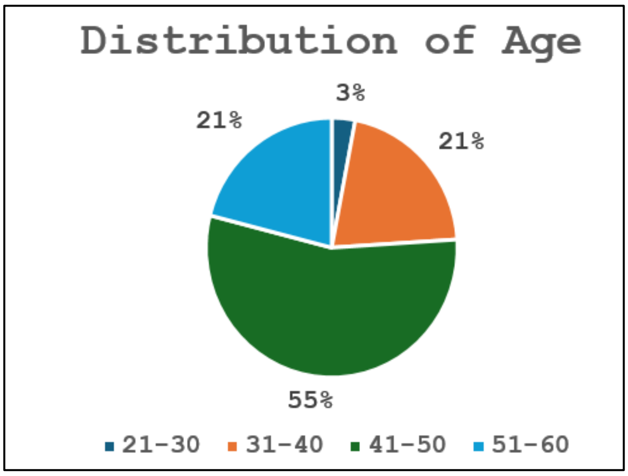

Fig 1 The Age Demographics

Thus, The majority participants in the research sample were middle-aged adults, reflecting the typical epidemiological pattern of primary hypertension.

➢ *Gender Distribution*

Among the 100 patients studied, 57 were females and 43 were males.

Table 2 Gender Distribution

Sex	Frequency	Percentage
Male	43	43%
Female	57	57%
Total	100	100%
M/F Ratio	75/100	

There was a slight female predominance in the present study

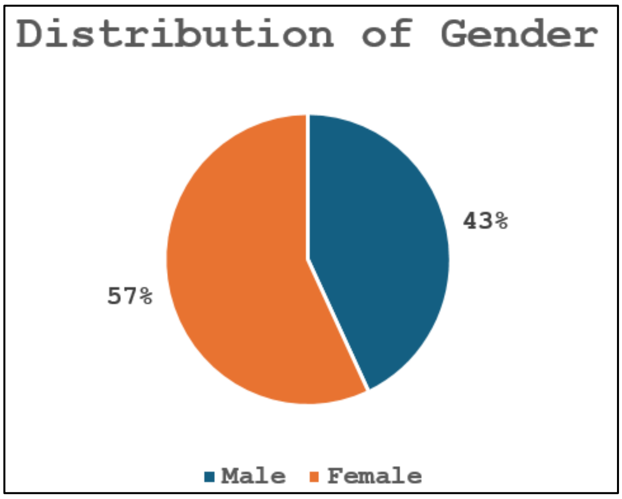

Fig 2 Distribution of Gender

➢ *Blood Pressure Profile of Study Population*

Table 3 Mean and SD of Blood Pressure

Parameter	Mean	SD	P Values
SBP	156.51	4.30	<0.0001(S)
DBP	89.72	2.74	<0.0001(S)

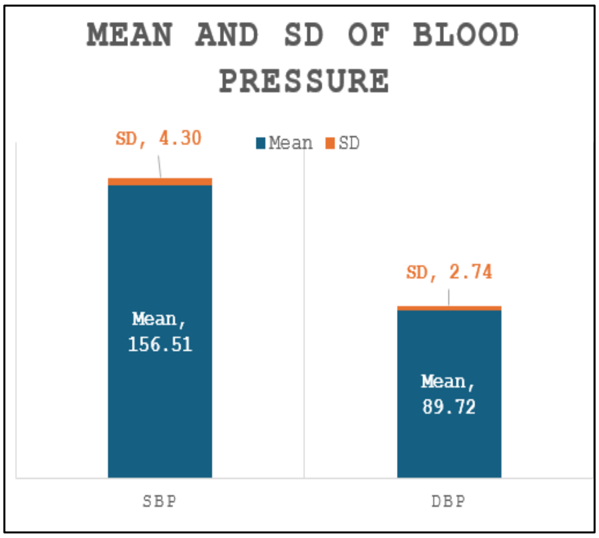

Fig 3 Mean and SD of BP

The average BP readings, including systolic and diastolic, were calculated for all participants.

For the majority patients had Stage 2 hypertension according to JNC-8 classification, demonstrated the study population had moderately elevated blood pressure levels.

➢ *Serum Vit-D Concentrations*

Serum vit-D3 concentrations measured in all participants.

The mean serum vit-D3 concentrations in the study population was:

21.92 ± 6.01 ng/ml

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Table 4 Mean and SD of Vitamin-D Levels

Parameter	Mean	SD	P Value
Vit-D(ng/dl)	21.93	6.01	<0.0001(S)

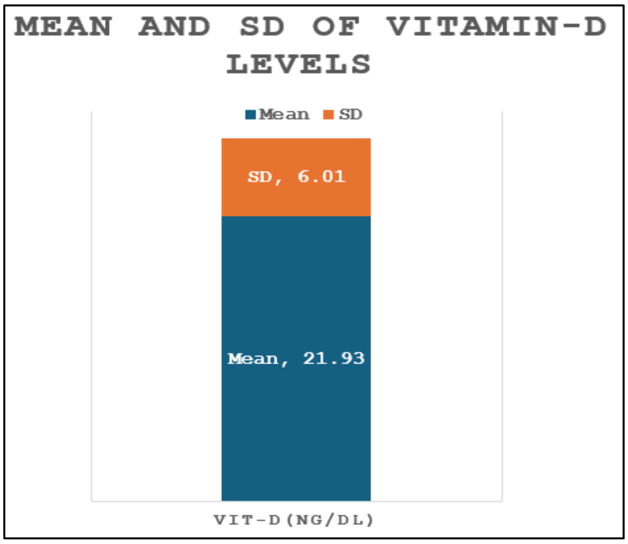

Fig 4 Mean and Standard Deviation of Vit- D Levels

This value falls within vit- D3 insufficiency range, indicating that most hypertensive patients in current research had less than ideal vit-D status.

- *Distribution of Vitamin D3 value*

Vit-D3 concentrations are classified into deficiency, insufficiency, and sufficiency categories.

Table 5 Distribution of Vitamin D Levels

Vit-D(ng/dl)	No of Cases	Percentage
Deficiency (<10)	10	10%
Insufficiency (10-30)	82	82%
Sufficiency (>30)	8	8%
Total	100	100%
Chi Sq P Value	<0.0001 (VS)	

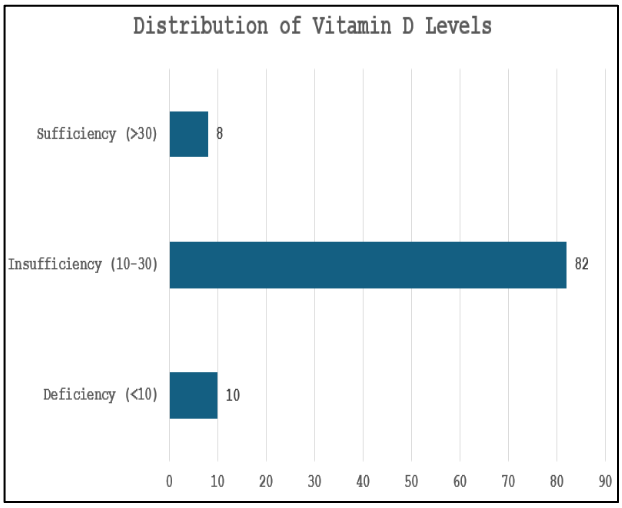

Fig 5 Distribution of Vitamin D Levels

The findings show that 92% of patients had suboptimal vitamin D levels (deficiency or insufficiency).

Only 8% of patients had sufficient vitamin D levels, indicating a very high prevalence of hypovitaminosis D among hypertensive patients in this cohort.

- *Association between Gender and Vitamin D Levels*

The mean vitamin D levels were analyzed according to gender.

Table 7 Association of Vitamin D Levels vs Gender

Gender	Mean	SD
Male	21.37	5.64
Female	22.34	6.30
Total	21.86	6.01
ANOVA P Value	**>0.005 (NS)**	

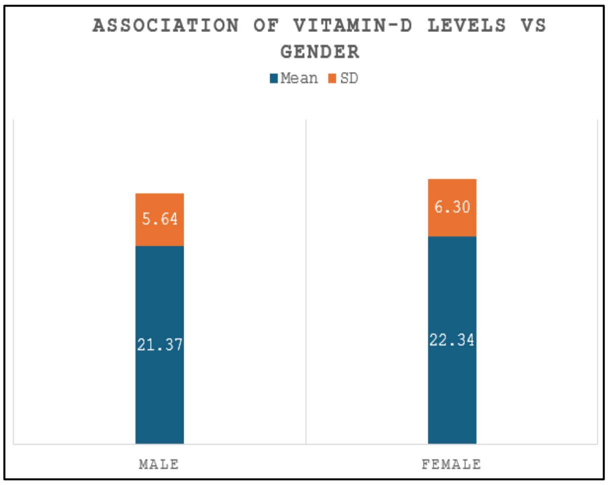

Fig 6 Association of Vit-D Concentrations vs Gender

Table 6 Association of Vitamin D Levels vs Age

Age	Mean	SD
21-30	26.83	4.65
31-40	20.08	5.72
41-50	22.61	5.67
51-60	21.27	6.95
Total	21.93	6.01
ANOVA P Value	0.00003(S)	

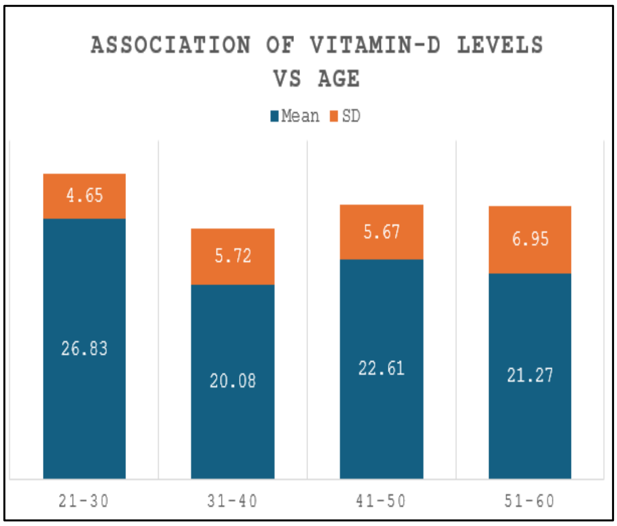

Fig 7 Association of Vit-D Concentrations vs Age

Statistical analysis showed no significant variation in vit- D concentrations among individuals of both sexes ($p > 0.05$). Therefore, sex failed seem to significantly influence vitamin D status in this research population.

- *Interrelationship Among Vit- D concentrations and Blood Pressure*

Utilizing correlation analysis, the association between serum vit-D levels and BP parameters.

Table 8 Association of Vit-D Levels vs Blood Pressure Parameter

Vit-D(ng/dl)	Parameter	Mean	SD	CHI SQ P VALUE
Deficiency (<10) N1=10	SBP	157.3	4.72	**<0.0001 (VS)**
	DBP	90.3	3.26	**<0.0001 (VS)**
Insufficiency (10-30) N2= 82	SBP	156.55	4.28	**<0.0001 (VS)**
	DBP	89.68	2.69	**<0.0001 (VS)**
Sufficiency (>30) N3=8	SBP	155.13	4.26	**<0.0001 (VS)**
	DBP	88.75	2.43	**<0.0001 (VS)**

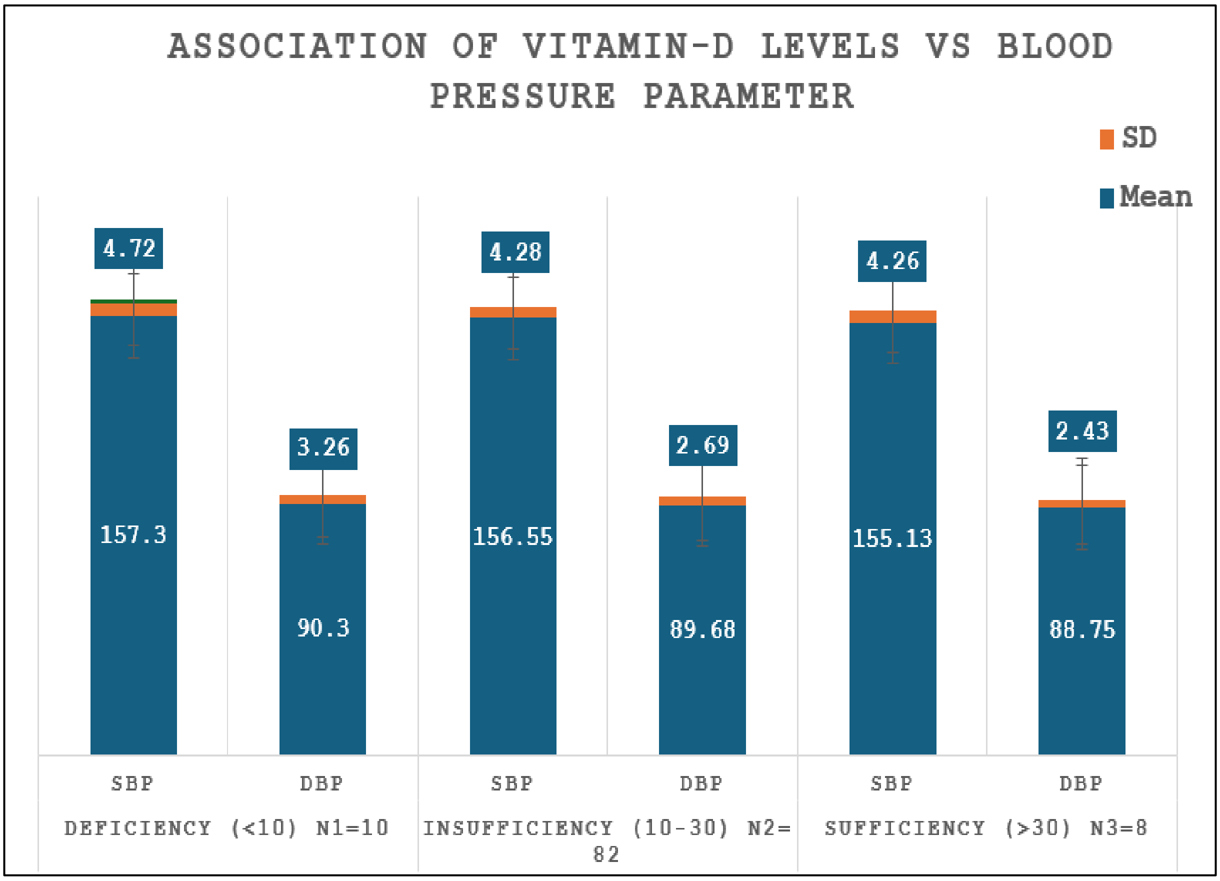

Fig 8 Association of Vit-D Concentrations vs BP

Table 9 ROC of Vitamin D Levels vs Blood Pressure Parameter

Vit-D(ng/dl)	Parameter	Mean	SD
Deficiency (<10) N1=10	SBP	157.3	4.72
	DBP	90.3	3.26
Insufficiency (10-30) N2= 82	SBP	156.55	4.28
	DBP	89.68	2.69
Sufficiency (>30) N3=8	SBP	155.13	4.26
	DBP	88.75	2.43
Total	SBP	156.51	4.30
	DBP	89.72	2.74
Anova P Value within groups	SBP	0.53	>0.005 (NS)
	DBP	0.48	>0.005 (NS)

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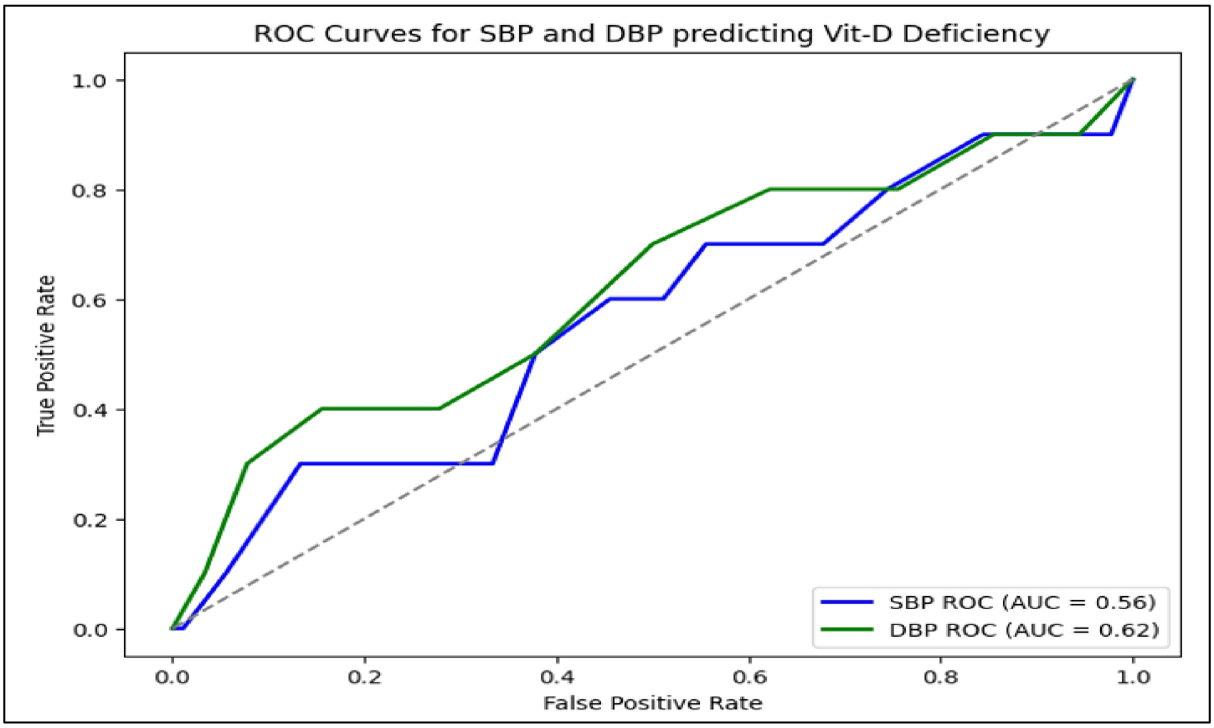

Fig 9 ROC Curves for SBP and DBP Predicting Vit-D Deficiency

Table 10 Correlation of SBP and DBP with vit-D Concentrations

Vit-D(ng/dl)	Parameter	Correlation
Deficiency (<10) N1=10	SBP	0.238
	DBP	0.241
Insufficiency (10-30) N2= 82	SBP	0.910
	DBP	0.872
Sufficiency (>30) N3=8	SBP	-0.143
	DBP	-0.120
Total	SBP	0.353
	DBP	0.277

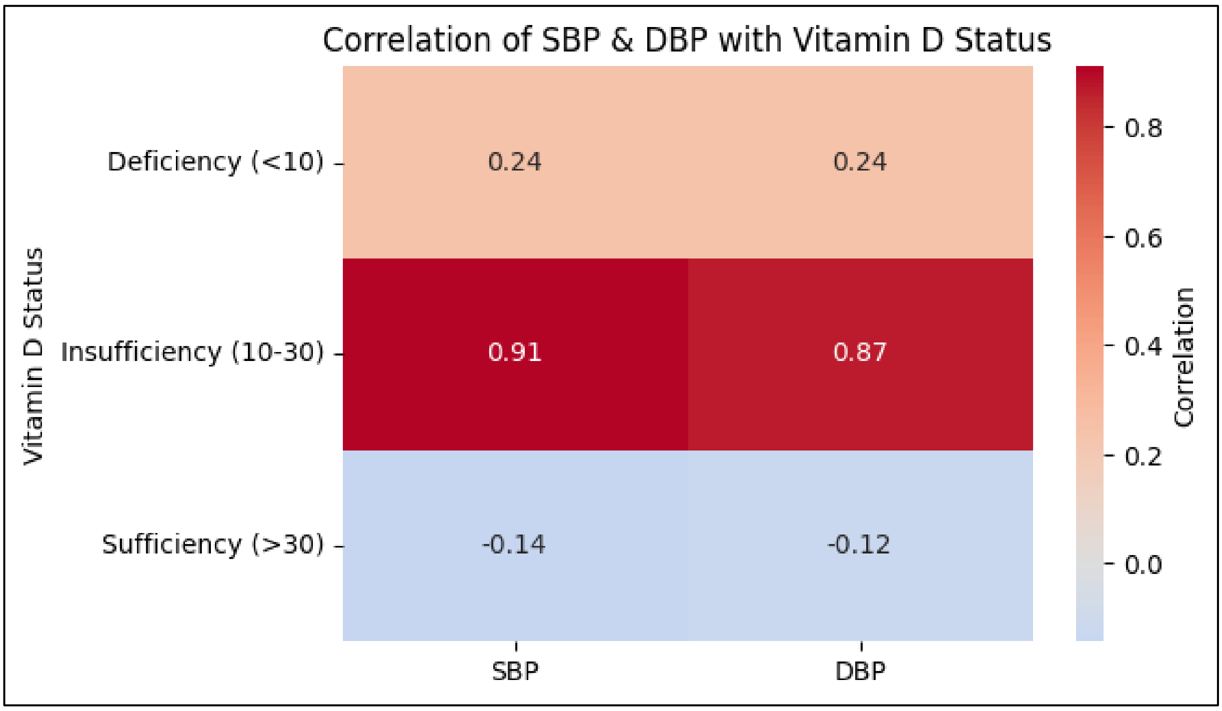

Fig 10 Correlation of SBP and DBP with vit-D Concentrations

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Serum vitamin D levels were found to be oppositely correlated with both systolic and diastolic blood pressure. This indicated decreased amounts of vit- D3 values were associated with higher blood pressure values.

➤ *Key Findings of the Study*

- The mean age of hypertensive patients was 45.63 ± 8.77 years.
- Females constituted 57% of the study population.
- Mean systolic blood pressure was 156.51 ± 4.30 mmHg.
- Mean diastolic blood pressure was 89.72 ± 2.74 mmHg.
- Mean serum vitamin D level was 21.92 ± 6.01 ng/ml.
- 92% of hypertensive patients had suboptimal vit- D concentrations.
- There was a strong negative relationship between vit-D3 levels and blood pressure.

IV. DISCUSSION

One of the main factors contributing to cardiac illness and death is hypertension. Worldwide. Several risk factors have been implicated in the pathogenesis of hypertension, including inheritedtendency, adiposity, genetic susceptibility, and physicaly inactive behaviour excessive salt intake, and metabolic abnormalities.

In recent years, vitamin D deficiency has emerged as a potential contributor to the evolution of hypertension through various physiological mechanisms.

The current research was conducted to investigate the link among vit- D levels and primary hypertension in patients attending a health care centre.

➤ *Age Distribution*

In current research, average participants were aged 45.63 ± 8.77 years, with the majority of participants belonging to the 40–50 year age group.

These findings are consistent with the natural epidemiological trend of hypertension, which tends to increase with advancing age.

Parallel findings were reported by Kota et al. and Bhandari et al., who found that hypertension commonly affects individuals in the fourth and fifth decades of life.

The escalating frequency of hypertension with age can be caused by multiple factors, including:

- Progressive arterial stiffness
- Endothelial dysfunction
- Reduced vascular compliance
- Increased peripheral vascular resistance

These changes collectively contribute to elevation of systemic blood pressure.

➤ *Gender Distribution*

In current research, 57% of the participants were females, while 43% were males.

This slight female majority explained by increased healthcare-seeking behavior among women or demographic variations in the hospital-based population.

Several population-based studies have reported similar prevalence rates of hypertension in both genders, although some studies indicate a higher prevalence in males in younger age groups.

In the present study, vitamin D levels did not differ significantly between males and females, suggesting that gender does not significantly influence vitamin D status among hypertensive patients.

➤ *Vitamin D Status in Hypertensive Patients*

The mean serum vitamin D level in the present study was 21.92 ± 6.01 ng/ml, which falls within the vitamin D insufficiency range.

- *A Very High Prevalence of Hypovitaminosis D Was Observed:*

✓ 10% had vitamin D deficiency
✓ 82% had vitamin D insufficiency
✓ Only 8% had sufficient vitamin D levels

Thus, 92% of hypertensive patients had suboptimal vitamin D levels.

This finding is consistent with several studies conducted worldwide.

Forman et al. reported that individuals with lower vitamin D levels had a significantly higher risk of developing hypertension.

Similarly, Kunutsor et al. demonstrated in a meta-analysis that every 10 ng/ml increase in vitamin D levels was associated with a 12% reduction in the risk of hypertension.

In India, vitamin D deficiency is paradoxically common despite abundant sunlight exposure. Possible reasons include:

- Reduced outdoor activity
- Urban lifestyle
- Air pollution
- Increased skin pigmentation
- Inadequate dietary intake
- Sequestration of vitamin D in adipose tissue in obese individuals

➤ *Relationship Between Vitamin D and Blood Pressure*

In this study, serum vitamin D levels showed a clear inverse association with both systolic and diastolic blood pressure measurements. Participants with lower vitamin D concentrations tended to have higher blood pressure values,

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indicating a possible link between vitamin D deficiency and hypertension.

This relationship may be explained through several physiological pathways. Vitamin D is known to negatively regulate the renin–angiotensin–aldosterone system; therefore, inadequate levels may lead to increased renin activity, promoting vasoconstriction and fluid retention, which elevate blood pressure. Additionally, vitamin D contributes to vascular health by supporting endothelial function and nitric oxide availability. A deficiency may impair these processes, resulting in increased vascular tone.

Alterations in calcium balance also play a role, as low vitamin D levels can increase intracellular calcium within vascular smooth muscle cells, leading to enhanced contraction and peripheral resistance.

Moreover, reduced vitamin D status has been linked with increased inflammatory mediators and oxidative stress, both of which contribute to vascular dysfunction and stiffness.

Taken together, these findings suggest that insufficient vitamin D may be involved in the pathogenesis of hypertension, although further research is needed to confirm a causal relationship.

➢ *Regulation of the Renin–Angiotensin–Aldosterone System*

Vitamin D plays a crucial role in regulating the renin–angiotensin–aldosterone system (RAAS).

Vitamin D acts as a negative endocrine regulator of renin gene expression.

- *Vitamin D Deficiency Leads to:*

✓ Increased renin production
✓ Increased angiotensin II levels
✓ Vasoconstriction
✓ Sodium retention
✓ Elevation of blood pressure

Experimental studies have shown that vitamin D receptor knockout mice develop hypertension due to activation of the RAAS system.

➢ *Endothelial Dysfunction*

Additionally vitamin D is crucial in maintaining endothelial function.

It increases the generation of endothelial nitric oxide and improves vascular relaxation.

- *Vitamin D Deficiency Leads to:*

✓ Decreased nitric oxide availability
✓ Increased oxidative stress
✓ Vascular smooth muscle proliferation
✓ Increased vascular resistance

These changes contribute to the development of hypertension.

➢ *Role of Parathyroid Hormone (PTH)*

A lack of vitamin D causes secondary hyperparathyroidism, resulting in elevated parathyroid hormone levels.

Elevated PTH levels may increase intracellular calcium concentration with in vascular smooth muscle cells, resulting in to increased vascular tone and elevated blood pressure.

➢ *Comparison with Other Studies*

The current study's conclusions are in line with several previously published studies.

Kunutsor et al. (2013) demonstrated that individuals with higher vit- D concentrations were associated with decreased risk of hypertension.

Burgaz et al. also reported an circulation vit- D concentrations and the risk of hypertension are inversely correlated.

However, randomized controlled trials evaluating Supplementing with vitamin D has resulted in varying, suggesting that vitamin D deficiency may act as a marker of cardiovascular risk rather than a direct causal factor.

Martins D et al[73]study found significant lesser mean 25-OHD in HTN Patients in contrast to healthy controls.

Tomaschitz and colleagues suggested that diminished vit-D concentrations influence BP by enhancing renin–angiotensin activity and reducing arterial flexibility. Both of these changes can contribute to a rise in vascular pressure. In currentresearch, patients with lower vit- D values also showed higher blood pressure measurements, which substantiates a possible biological relationship between inadequate vit- D concentrations and HTN.

An Indian study by Kota et al. found that vit- D deficiency was highly prevalent among hypertensive individuals when compared with normotensive controls. The authors proposed that vit- D insufficiency may be an additional modifiable factor contributing to HTN in the Indians. The current research demonstrated a high frequency of vit-D insufficiency among hypertensive patients.

➢ *Clinical Implications*

The significant frequency of vitamin D deficiency found in this study implies that vitamin D deficiency may be an important modifiable risk factor in hypertensive patients.

Patients with hypertension who are screened for vitamin D deficiency may benefit from vitamin D supplements and lifestyle interventions.

➢ *Limitations of the Study*

The current research has some limitations:

- The sample size was relatively small.

- The study was carried out in a single tertiary care facility, which might restrict generalizability.
- Confounding variables include BMI, dietary habits, sunlight exposure, and physical activity were not assessed.
- As this was a cross-sectional study, causal connection between low levels of vitamin D and hypertension cannot be established.

➢ *Summary of Discussion*

The current study investigated the connections between primary HTN and blood vit- D content in persons receiving treatment at a healthcare facility. One of the the main causes of cardiovascular disease in the globe, hypertension still places a heavy strain on healthcare systems. While ageing, overweight people, genetics, and bad lifestyle choices are the primary causes of high BP, vit- D's potential impact on cardiovascular control has received more attention. According to the study's findings, persons with primary HTN may have greater BP when their vit- D concentrations are lower.

The middle-aged group comprised a sizable fraction of the participants, especially those in the 41–50 age range. The known increase in HTN in middle and later adulthood is consistent with this age pattern. As people age, the arterial wall gradually undergoes structural changes that result in decreased elasticity and increased vascular stiffness. These alterations may hinder regular blood flow and lead to a long-term rise in blood pressure. The current study's age distribution thus mirrors the typical clinical pattern of primary HTN.

Compared to men, women made up a slightly higher percentage of the Research subjects. Vit-D concentrations did not differ significantly between the sexes despite this distributional disparity. This result implies that vit- D levels in hypertensive people may not be influenced by gender on their own. Previous research have revealed similar findings, showing similar vitamin D status in both men and women with HTN. Rather than being a disease-related difference, the higher proportion of female participants might just be a reflection of local patient attendance trends.

The growing number of low vit-D concentrations in the research population was one of the most noteworthy findings. The majority of patients showed either insufficiency or deficiency, and the average serum vit-D content was within the inadequate range. Only a tiny proportion displayed values that were deemed sufficient. This pattern indicated significant proportion of people with primary HTN have inadequate vit-D concentrations. Similar outcomes have been reported in a number of earlier investigations, suggested people with high BP typically experience vitamin D deficiency. Deficiencies can arise even in tropical nations due to inadequate nutritional intake, darker skin pigmentation, indoor lifestyles, and little sun exposure.

BP and vit- D concentration were found to be oppositely correlated; those with lower vit-D concentrations tended to have higher SBP and DBP readings. This finding increased possibility that vit-D may affect BP control mechanisms.

RAAS, which is crucial for preserving fluid balance and vascular tone, is thought to be regulated by vit- D. Increased renin activity brought on by low vit- D concentrations result in constriction of vessels and salt retention. An increase in arterial pressure may result from these alterations. This procedure provides a possible explanation for the correlation found during this research.

Endothelial cells release NO, vit- D promotes vascular health. Vascular relaxation and responsiveness are maintained by NO. Low levels of vit- D can alter endothelial function and increase vascular resistance. This could make HTN more likely to develop. Furthermore, a lack of vit-D might result in an increase in parathyroid hormone secretion, which can increase BP and improve vascular smooth muscle contraction.

The current results are in line with earlier research proving a connection between HTN and lower circulating vit-D concentrations. According to multiple researches, people who don't get enough vit- D are more likely to have high BP. However, results from vit-D supplementating interventional research have been mixed. This indicates vit-D insufficiency may be one of the contributing variables to cardiac risk rather than the main cause of HTN

From a clinical standpoint, the substantial number of low levels of vit- D in HTN patients implies that assesing vitamin D concentrations may be useful in some individuals. Early intervention through dietary habits, lifestyle guidance, and and supplements where necessary may be made possible by the identifying the deficiencies. Vit- D correction may become a supportive tool in total cardio care, even if it might not be able to replace BP lowering medicines on its own.

While evaluating these findings, it is important to recognize certain limitations. The research was conducted at a single institution and had a rather limited number of participants which may restrict the findings' broader applicability. Significant factors like physical activity, exposure of sun, food intake, and BMI were not thoroughly examined. It is unable to establish a direct causal link between Deficiency of vit-D and HTN due to the cross-sectional study method.

Overall, the study finds that patients with primary HTN frequently have inadequate vitamin D levels and that higher blood pressure readings are linked to lower vitamin D concentrations. These results imply that vit- D may play a role in controlling BP. To find out if treating vit-D deficiency can enhance long-term cardiovascular related outcomes in hypertensive patients, more extensive further research are required.

V. CONCLUSION

Our findings indicate that Systolic blood pressure has a significant inverse association with serum vitamin D levels. Additionally, it was found that among the hypertensive people, systolic blood pressure had an independent impact on serum vitamin D levels. However, as it was outside the

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authority of this investigation, blood pressure reduction with unneeded vitamin D administration was not carried out. In order to lower the risk of consequences from high blood pressure, those with suboptimal serum vitamin D levels must take calciferol supplements. When vitamin D insufficiency is identified at various ages, appropriate guidelines that can suggest the appropriate dosage of supplementation are needed.

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