Original Article

"Impact of Vitamin D Supplementation on Blood Pressure in Individuals with Hypertension and Vitamin D Deficiency."

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ABSTRACT:

Background: *Vitamin D deficiency has been increasingly implicated in the pathogenesis of hypertension through its regulatory effects on the renin–angiotensin system and vascular endothelial function.*

Objectives: *This study aimed to evaluate the impact of high-dose vitamin D supplementation on blood pressure control in hypertensive individuals with concurrent vitamin D deficiency.*

Methods: *A randomized, double-blind, placebo-controlled clinical trial was conducted at Holy Family Medical College and Hospital, Dhaka, from January 2022 to January 2023. A total of 48 adult hypertensive patients with vitamin D deficiency (serum 25(OH)D <30 ng/ml) were enrolled and randomly assigned to either the Vitamin D Group (VDG, n=24) or Placebo Group (PG, n=24). The VDG received 50,000 IU of oral cholecalciferol weekly for 8 weeks, while the PG received a matching placebo. Baseline and post-intervention measurements included systolic (SBP), diastolic (DBP), and mean arterial pressure (MAP), along with serum 25(OH)D, parathormone, calcium, and electrolytes.*

Results: *After 8 weeks, VDG showed significant reductions in SBP (−7.2 mmHg), DBP (−3.6 mmHg), and MAP (−4.8 mmHg) compared to negligible changes in the PG. Serum 25(OH)D levels increased substantially in VDG (+33.5 ng/ml vs. +2.0 ng/ml in PG), with normalization observed in 95.8% of VDG participants. Parathormone levels decreased significantly in VDG (−21.4 pg/ml), accompanied by a modest rise in serum calcium. No adverse effects were reported, and compliance was high in both groups.*

Conclusion: *High-dose weekly vitamin D supplementation effectively improved vitamin D status and contributed to significant reductions in blood pressure among deficient hypertensive patients. These findings support the use of vitamin D as a safe and beneficial adjunct therapy for hypertension management in vitamin D-deficient populations.*

Key Words:
Vitamin D, Hypertension, Blood Pressure, 25(OH)D, Supplementation, Randomized Controlled Trial

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Introduction

Hypertension remains one of the most prevalent chronic diseases globally and a major contributor to cardiovascular morbidity and mortality. According to recent estimates, approximately 1.28 billion adults aged 30–79 years have hypertension, with two-thirds living in low- and middle-income countries1. Despite the availability of effective pharmacological treatments, many individuals fail to achieve optimal blood pressure (BP) control, indicating the need for adjunctive, non-pharmacologic interventions2. Vitamin D, primarily synthesized through skin exposure to sunlight, has emerged as a modifiable factor in cardiovascular health. Its role extends beyond bone and mineral metabolism, influencing vascular tone, endothelial function, and renin–angiotensin system activity3. Several observational studies have reported an inverse association between serum 25-hydroxyvitamin D [25(OH)D] levels and BP, suggesting that vitamin D deficiency may contribute to hypertension pathophysiology4,5.

In Bangladesh and other South Asian countries, vitamin D deficiency is alarmingly common, even in sunny environments, due to limited outdoor activity, traditional clothing, and inadequate dietary intake6. This deficiency is particularly concerning among individuals with hypertension, where endothelial dysfunction and increased arterial stiffness further worsen cardiovascular outcomes7. While randomized controlled trials have provided mixed findings on the BP-lowering effects of vitamin D supplementation, differences in dosage, duration, population characteristics, and baseline vitamin D status could explain the variability8.

Given the high burden of both hypertension and vitamin D deficiency in South Asia, this study aims to evaluate the effect of high-dose vitamin D supplementation on BP reduction in hypertensive adults with confirmed deficiency. The outcomes may help clarify the therapeutic potential of vitamin D in cardiovascular risk management and support region-specific recommendations.

Methodology

This randomized, double-blind, placebo-controlled clinical trial was conducted at Holy Family Medical College and Hospital, Dhaka from January 2022 to January 2023. The study enrolled 48 adult participants aged 30–60 years with previously diagnosed hypertension and confirmed vitamin D deficiency, defined as serum 25-hydroxyvitamin D [25(OH)D] levels below 30 ng/ml. Participants were randomly allocated into two equal groups (n=24 each) using computer-generated randomization. The intervention group (Vitamin D Group, VDG) received 50,000 IU of oral vitamin D3 (cholecalciferol) once weekly for 8 weeks, while the control group (Placebo Group, PG) received matching placebo capsules. Both groups continued their prescribed antihypertensive medications during the trial. Primary outcomes included changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP), measured using a calibrated mercury sphygmomanometer following standard protocols. Secondary outcomes included changes in serum 25(OH)D, parathormone, calcium, magnesium, sodium, and potassium levels. Blood pressure and biochemical parameters were assessed at baseline and at the end of the 8-week intervention. All biochemical tests were conducted at the hospital's central laboratory using standard chemiluminescence and colorimetric assays. Compliance was monitored through capsule counts and weekly phone follow-ups. Participants were excluded if they missed more than two doses or changed antihypertensive regimens during the study. Data were analyzed using SPSS version 26. Paired and independent t-tests were used to assess intra and intergroup differences, with p-values <0.05 considered statistically significant. The Kolmogorov–Smirnov test was applied to assess data normality. Non-parametric tests were applied for skewed data. Categorical variables were analyzed using the Chi-square or Fisher's exact test as appropriate. Pearson correlation analysis was performed to assess the relationship between changes in serum 25(OH)D and blood pressure parameters. Ethical approval was obtained from the Institutional Review Board, and informed written consent was secured from all participants.

Results

Demographic and baseline characteristics

The Vitamin D group (VDG) and placebo group (PG) were well-matched demographically. The mean age was 42.1 years in VDG and 43.3 years in PG. Female participants predominated in both groups (62.5% in VDG vs. 58.3% in PG). The BMI was slightly higher in VDG (29.5 ± 3.8 kg/m²) compared to PG (28.8 ± 3.5 kg/m²), with comparable waist circumferences (111.2 cm vs. 110.6 cm). Sunlight exposure $\leq$1 hour/day was reported

by 91.7% in VDG and 83.3% in PG. Family history of hypertension was present in 66.7% (VDG) and 62.5% (PG) [Table 1].

Table 1: Demographic and baseline characteristics of participants (n=48)

Variable	Vitamin D Group (n=24)	Placebo Group (n=24)
Age (years, mean ± SD)	42.1 ± 6.0	43.3 ± 5.8
Sex (Male/Female)	9 (37.5%) / 15 (62.5%)	10 (41.7%) / 14(58.3%)
BMI (kg/m², mean ± SD)	29.5 ± 3.8	28.8 ± 3.5
Waist Circumference (cm,1 mean ± SD)	11.2 ± 2.3	110.6 ± 2.4
Sunlight Exposure ≤1hr/day	22 (91.7%)	20 (83.3%)
Abdominal Obesity	14 (58.3%)	13 (54.2%)
Family History of Hypertension	16 (66.7%)	15 (62.5%)
Duration of Antihypertensive Use (weeks)	8.3 ± 2.5	8.1 ± 2.8

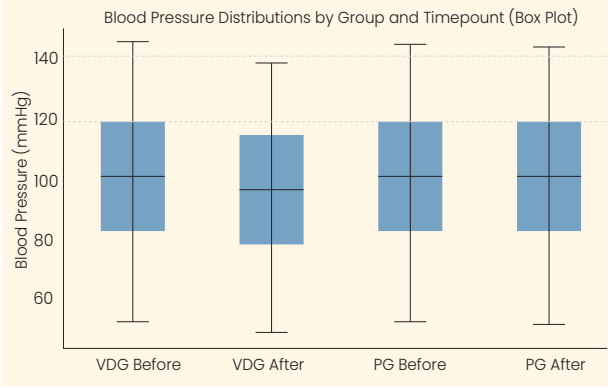
Both groups started with similar biochemical profiles, indicating balanced baseline status. Serum 25(OH)D was 17.8 ± 7.2 ng/ml in VDG and 18.6 ± 6.9 ng/ml in PG. Parathormone levels were also almost similar (47.3 pg/ml vs. 44.5 pg/ml), as were calcium levels (9.3 mg/dl in VDG vs. 9.4 mg/dl in PG). Electrolyte levels such as magnesium (1.9 vs. 2.0 mg/dl), phosphorus (3.4 vs. 3.5 mg/dl), sodium (140.4 vs. 140.2 mEq/L), and potassium (4.3 vs. 4.4 mEq/L) showed no significant group difference.

Table 2: Baseline serum biochemical parameters (n=48)

Parameter	Vitamin D Group (Mean ± SD)	Placebo Group (Mean ± SD)
25(OH) Vitamin D (ng/ml)	17.8 ± 7.2	18.6 ± 6.9
Parathormone (pg/ml)	47.3 ± 17.1	44.5 ± 16.4
Calcium (mg/dl)	9.3 ± 0.3	9.4 ± 0.3
Magnesium (mg/dl)	1.9 ± 0.2	2.0 ± 0.2
Phosphorus (mg/dl)	3.4 ± 0.4	3.5 ± 0.5
Sodium (mEq/L)	140.4 ± 1.5	140.2 ± 1.6
Potassium (mEq/L)	4.3 ± 0.3	4.4 ± 0.3

Post-intervention, the Vitamin D group experienced meaningful reductions in SBP (from 146.2 ± 4.2 to 139.0 ± 7.1 mmHg), DBP (93.1 ± 2.2 to 89.5 ± 3.6 mmHg), and MAP (110.8 ± 2.5 to 106.0 ± 4.1 mmHg). In contrast, the placebo group showed negligible change in SBP (145.7 ± 4.4 to 145.0 ± 5.2 mmHg), DBP (92.9 to 93.2 mmHg), and MAP (110.5 to 110.4 mmHg).

Figure 1: Blood Pressure parameters pre- and post-intervention (n=48)



After 8 weeks, VDG showed a remarkable increase in 25(OH)D levels by +33.5 ± 12.7 ng/ml, compared to just +2.0 ± 8.4 ng/ml in PG. Parathormone levels dropped by −21.4 pg/ml in VDG versus −1.8 pg/ml in PG. Serum calcium increased by +0.4 mg/dl in VDG, while PG had a slight decline of −0.1 mg/dl.

Table 3: Change in serum biochemical markers after 8 weeks (n=48)

Parameter	VDG Change (Mean ± SD)	PG Change (Mean ± SD)
25(OH) Vitamin D (ng/ml)	+33.5 ± 12.7	+2.0 ± 8.4
Parathormone (pg/ml)	−21.4 ± 14.3	−1.8 ± 11.2
Calcium (mg/dl)	+0.4 ± 0.3	−0.1 ± 0.2

Vitamin D levels normalized in 95.8% of VDG participants (23 out of 24), whereas only 8.3% of PG participants (2 out of 24) achieved sufficiency. The overwhelming difference underscores the therapeutic potency of 50,000 IU/week vitamin D, as spontaneous normalization was rare in the control group (91.7% remained deficient) [Table 4].

Table 4: Vitamin D normalization status post-intervention (n=48)

Status	VDG [n (%)]	PG [n (%)]
Normalized Vitamin D	23 (95.8%)	2 (8.3%)
Still Deficient	1 (4.2%)	22 (91.7%)

Table 5 shows that all participants (100%) in both groups tolerated the intervention without reporting side effects. Only one participant (4.2%) in VDG missed more than two doses, while PG had full compliance (0% missed doses).

Table 5: Adverse Events and Compliance (n=48)

Event	VDG [n (%)]	PG [n (%)]
No Side Effects	24 (100%)	24 (100%)
Mild Nausea	0 (0%)	0 (0%)
Missed >2 Doses	1 (4.2%)	0 (0%)

A strong negative correlation was found between changes in 25(OH)D and SBP ($r = -0.65$, $p = 0.001$), and a moderate correlation with DBP ($r = -0.48$, $p = 0.014$).

Table 6: Correlation between Vitamin D change and Blood Pressure change (n=48)

Variable Correlated	Correlation Coefficient (r)	P-value
Δ25(OH)D vs ΔSBP	−0.65	0.001
Δ25(OH)D vs ΔDBP	−0.48	0.014

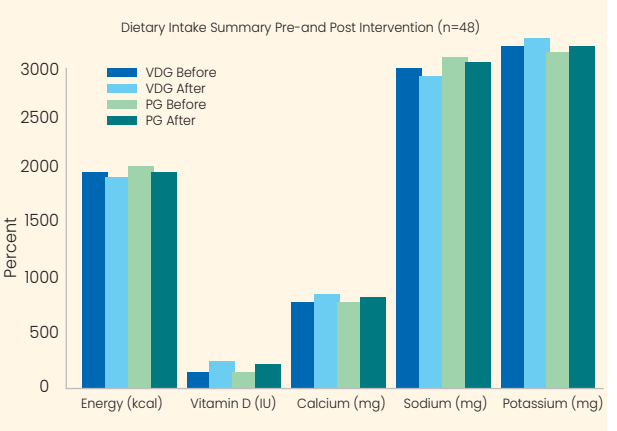
Participants with higher BMI (>30) experienced greater reductions in SBP in the Vitamin D group (−7.5 mmHg) compared to those with BMI 25–30 (−6.8 mmHg) and <25 (−5.2 mmHg). In contrast, the placebo group had minimal SBP reductions across all BMI groups (−1.2 mmHg in obese, −0.9 mmHg in overweight, and −0.5 mmHg in normal BMI).

Table 7: Subgroup analysis – Mean SBP reduction by BMI category (n=48)

BMI Category	Mean SBP Reduction (VDG)	Mean SBP Reduction (PG)
<25	−5.2 mmHg	−0.5 mmHg
25–30	−6.8 mmHg	−0.9 mmHg
>30	−7.5 mmHg	−1.2 mmHg

Both groups had similar dietary intakes, with VDG consuming 1950 kcal/day pre-intervention and 1920 post-intervention, while PG consumed 2000 and 1980 kcal/day respectively. Daily vitamin D intake increased modestly in both groups (180 to 210 IU in VDG, 175 to 190 IU in PG), but only the VDG showed clinical correction. Calcium intake rose slightly in VDG (760 to 800 mg), with similar patterns for sodium and potassium.

Figure 2: Dietary Intake Summary Pre- and Post-Intervention (Mean ± SD, n=48)



Discussion

Socio-demographic analysis of this study revealed that most participants were middle-aged adults with a predominance of females (over 60% in both groups). A majority reported limited sunlight exposure (<1 hour/-day), highlighting behavioral and occupational patterns that may predispose to vitamin D deficiency. A notable disparity was observed in obesity prevalence, with 56–58% of participants having abdominal obesity, which is known to impair vitamin D bioavailability and exacerbate hypertension risk19. Another disparity relates to gender differences, as previous studies indicate that women in South Asia have a significantly higher prevalence of vitamin D deficiency compared to men due to cultural clothing practices and reduced outdoor activity20. These factors likely influenced the baseline deficiency rates observed in our study.

Our findings align with recent studies that show a direct link between vitamin D status and vascular health. A 2021 meta-analysis by Golzarand et al. found that vitamin D supplementation significantly reduced SBP and DBP in individuals with baseline deficiency9. Similarly, a large cohort study in Korea reported that lower serum 25(OH)D levels were associated with increased hypertension risk over time10. In the current study, the correction of vitamin D deficiency also led to decreased parathormone levels and increased serum calcium, suggesting improved mineral metabolism. Elevated parathyroid hormone has been linked to increased vascular resistance and BP elevation, further supporting the mechanistic basis of our findings11. Our

results are particularly relevant in South Asian settings, where both vitamin D deficiency and hypertension are highly prevalent. An Irani study reported higher prevalence of hypovitaminosis D among hypertensive adults, with a significant correlation with elevated BP12. It is important to note that several previous trials have yielded mixed results regarding vitamin D's antihypertensive effects. For instance, the ViDA trial by Scragg et al. (2017) showed no significant BP change with monthly vitamin D supplementation in a general population cohort13. However, their use of bolus dosing and inclusion of normotensive individuals may account for the lack of observed effect.

Our study differs in its use of a high weekly dose (50,000 IU), targeted population with confirmed deficiency, and consistent monitoring. Recent evidence suggests that daily or weekly dosing may be more physiologically appropriate than monthly boluses14. Moreover, the strong inverse correlation observed in our study between Δ25(OH)D and ΔSBP ($r = -0.65$) underscores the dose-response relationship. Furthermore, the absence of adverse events and high adherence rate indicate that this regimen is safe and feasible in outpatient clinical settings. These findings are consistent with prior safety assessments by Tóth BE et al., who reported minimal side effects in high-dose protocols15. Our subgroup analysis also revealed greater BP reduction among obese participants (BMI >30), supporting the theory that individuals with higher adiposity may be more responsive to vitamin D supplementation due to volumetric dilution effects or enhanced baseline deficiency16. This echoes findings by Vimaleswaran et al., who reported stronger effects in obese hypertensive populations17.

Nevertheless, our data contribute to the growing evidence base advocating for individualized, deficiency-targeted vitamin D interventions in blood pressure management protocols, particularly in resource-constrained, sun-rich yet deficiency-prone regions like South Asia18.

Conclusion

This study demonstrated that high-dose weekly vitamin D supplementation significantly improves blood pressure control in hypertensive patients with vitamin D deficiency. The intervention led to substantial reductions in SBP, DBP, and MAP, along with marked improvements in serum 25(OH)D levels and parathormone regulation. These findings suggest that vitamin D may serve as a safe and effective adjunct therapy for hypertension management. Given the high prevalence of deficiency in South Asian populations, targeted supplementation could offer valuable public health benefits. Further long-term, large-scale studies are warranted to confirm these outcomes.

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