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Original Research Article

Evaluating the Correlation and Regression between Serum Vitamin D Levels and Blood Pressure Components

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Abstract

Background: Vitamin D deficiency is associated with cardiovascular dysregulation and increased blood pressure; however, evidence in pregnant women in South Asia remains limited. This study aimed to evaluate the correlation and regression between maternal serum vitamin D levels and blood pressure components during late pregnancy. ***Methods:*** A hospital-based case–control study was conducted at Sir Salimullah Medical College Mitford Hospital, Dhaka, from March 2019 to March 2020, involving 106 pregnant women (53 preeclamptic and 53 normotensive). Serum 25-hydroxyvitamin D [25(OH)D] levels were measured using a chemiluminescence immunoassay and categorized as deficient (≤20 ng/mL), insufficient (21–29 ng/mL), or sufficient (≥30 ng/mL). Blood pressure was recorded according to standard protocols. Correlation and linear regression analyses were performed using SPSS version 23.0, with significance set at $p < 0.05$. ***Results:*** Serum vitamin D levels were inversely correlated with both systolic ($r = –0.449$, $p < 0.001$) and diastolic ($r = –0.449$, $p < 0.001$) blood pressures. Regression analysis indicated that each 1 ng/mL rise in serum vitamin D corresponded to a decrease of 1.68 and 1.2 mmHg in systolic and diastolic pressure, respectively. Sun exposure duration and antenatal attendance were positively associated with vitamin D sufficiency. ***Conclusion:*** Maternal serum vitamin D concentration was inversely associated with systolic and diastolic blood pressures. Maintaining adequate vitamin D levels through sunlight exposure and supplementation may support cardiovascular stability during pregnancy.

Keywords: Vitamin D, Blood pressure, Pregnancy, Correlation, Regression.

INTRODUCTION

Vitamin D, a secosteroid hormone primarily known for its role in calcium homeostasis and bone metabolism, has emerged as a crucial modulator of cardiovascular and metabolic health [1]. Beyond its skeletal effects, vitamin D receptors (VDRs) are widely expressed in endothelial cells, vascular smooth muscle, and cardiac tissue, indicating their potential influence on vascular tone and blood pressure regulation [2]. The discovery that vitamin D deficiency is associated with increased cardiovascular morbidity has prompted extensive research into its relationship with hypertension, which is a leading cause of maternal and fetal complications during pregnancy [3].

During normal pregnancy, a physiological decline in peripheral vascular resistance and a rise in plasma volume ensure adequate uteroplacental perfusion [4]. However, disturbances in these adaptive mechanisms—often observed in hypertensive disorders such as preeclampsia—result in elevated blood pressure and reduced placental flow. Vitamin D deficiency may contribute to these pathophysiological alterations by

multiple mechanisms. It inhibits renin gene transcription via a VDR-dependent pathway, thereby modulating the renin–angiotensin–aldosterone system (RAAS). Reduced vitamin D bioavailability enhances vascular sensitivity to angiotensin II, leading to vasoconstriction and hypertension [5]. Furthermore, vitamin D has been shown to suppress proinflammatory cytokines, reduce oxidative stress, and regulate endothelial nitric oxide synthesis—all factors that influence blood pressure homeostasis [6,7].

Several studies have reported inverse associations between serum 25-hydroxyvitamin D [25(OH)D] levels and systolic or diastolic blood pressure in both general and pregnant populations. Singla et al. demonstrated significant negative correlations between serum vitamin D concentrations and both systolic ($r = -0.37$) and diastolic ($r = -0.39$) blood pressures [8]. Such findings suggest that suboptimal vitamin D levels may predispose pregnant women to hypertensive disorders by impairing vascular and metabolic function.

In South Asian countries, including Bangladesh, vitamin D deficiency remains highly prevalent, despite abundant sunlight [9]. Contributing factors include limited sun exposure due to cultural clothing practices, urban residence, air pollution, and inadequate dietary intake. In pregnancy, these challenges are compounded by increased metabolic demands and physiological hemodynamic stress [10]. Since both vitamin D deficiency and hypertension are common in this population, elucidating their interrelationship is essential to improve maternal outcomes.

This study was therefore conducted to evaluate the correlation and regression between maternal serum vitamin D levels and blood pressure components (systolic and diastolic) in late pregnancy. Unlike analyses focusing solely on preeclampsia as a binary outcome, this investigation aimed to explore the continuous relationship between serum vitamin D concentration and blood pressure parameters, offering insight into how vitamin D status may influence vascular physiology during pregnancy.

METHODOLOGY & MATERIALS

This hospital-based case–control study was conducted at the Department of Obstetrics and Gynecology, Sir Salimullah Medical College Mitford Hospital, Dhaka, from March 2019 to March 2020. A total of 106 pregnant women aged 18–35 years with gestational ages ranging from 28 to 40 weeks were enrolled—53 preeclamptic (case) and 53 normotensives (control).

Sample Selection

Inclusion Criteria

- Singleton pregnancy between 28–40 weeks of gestation
- Maternal age 18–35 years
- Women with or without hypertension, as defined by standard diagnostic criteria

Exclusion Criteria

- Chronic hypertension or chronic kidney disease
- Diabetes mellitus (pre-existing or gestational)
- Autoimmune disorders
- Multiple gestation
- Current intake of vitamin D supplementation

Data Collection and Study Procedure

Participants were enrolled consecutively after meeting eligibility criteria and providing informed written consent. Data collection included both interviews and clinical measurements. A pretested semi-structured questionnaire captured socio-demographic data, obstetric history, antenatal check-up frequency, and details of sun exposure (timing and duration). Blood pressure was measured following standard protocol using a mercury sphygmomanometer after ten minutes of rest. The systolic blood pressure (SBP) was recorded at the first Korotkoff sound, and diastolic blood pressure (DBP) at the disappearance of the sound.

Venous blood samples (5 mL) were collected aseptically, allowed to clot, and centrifuged at 4400 rpm for 10–15 minutes. Serum was separated and analyzed for 25-hydroxyvitamin D concentration using the Atellica™ Analyzer (Siemens Healthineers, USA) employing a chemiluminescence immunoassay method. Vitamin D levels were classified as deficient (≤20 ng/mL), insufficient (21–29 ng/mL), or sufficient (≥30 ng/mL).

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Review Board of Sir Salimullah Medical College Mitford Hospital. Informed written consent was taken from each participant. Privacy and confidentiality were strictly maintained. No participant was exposed to additional medical risk, and all procedures adhered to the principles of the Declaration of Helsinki.

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 23.0. Quantitative variables were expressed as mean ± standard deviation (SD), and categorical data as frequency and percentage. The chi-square test and Fisher's exact test were applied for categorical comparisons, and Student's t-test for continuous variables. Pearson correlation coefficients were computed to assess associations between serum vitamin D levels and blood pressure (SBP and DBP). Linear regression analysis was performed to quantify the relationship. A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1: Baseline characteristics of respondents (n = 106)

Obstetric variables		Case Group (n=53)	Control Group (n=53)	P-value
Gestational age	Mean ± SD	36.94 ± 2.31	36.57 ±2.80	
Gravida	Primigravida	30 (56.6)	29 (54.7)	0.845
	Multigravida	23 (43.4)	24 (45.3)	
BMI (kg/m^2)	Normal	11(20.8)	17 (32.1)	
	Over weight	35(66.0)	30 (56.6)	
	Obese	7(13.2)	6 (11.3)	
	Mean ± SD	27.11 ± 2.55	27.02 ± 2.90	0.868
Antenatal Checkup	Yes	29 (54.7)	45 (84.9)	0.001
Use of Burqa	Yes	39 (73.6)	31 (58.5)	0.101
	No	14 (26.4)	22 (41.5)	

Table 1 compares gestational age, gravida, BMI, antenatal care (ANC) status, and veil use between the two groups. No significant differences were observed in gravida, BMI, or veil use, whereas regular ANC attendance was significantly higher among normotensive women (p = 0.001).

Table 2: Distribution of respondents according to sun exposure by group (n=106)

Exposure to sun	Case Group (n=53)	Control Group (n=53)	p-value
Morning	22 (41.5)	29 (54.7)	0.392
Noon	20 (37.7)	15 (28.3)	
Afternoon	11 (20.8)	9 (17.0)	
Time of exposure			
<15 min	14 (26.4)	20 (37.8)	0.386
15-30 minutes	31 (58.5)	28 (52.8)	
>30 minutes	8 (15.1)	5 (9.4)	

There was no statistically significant difference observed between the case and control group regarding time and duration of sun exposure (p > 0.05).

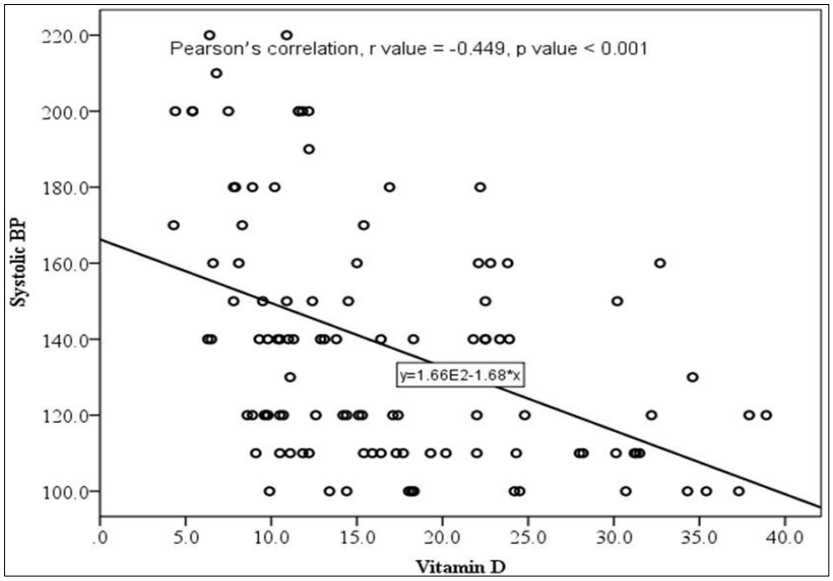

Figure 1: Scatter diagram showing correlation and regression between vitamin D and systolic blood pressure (SBP)

There was a negative correlation (r = -0.449) observed between maternal vitamin D and systolic blood pressure, which was statistically significant (p<0.05). The linear regression equation was y = 166 – 1.68*x, i.e. one unit of vitamin D was increased, systolic blood pressure was decreased 1.68 times.

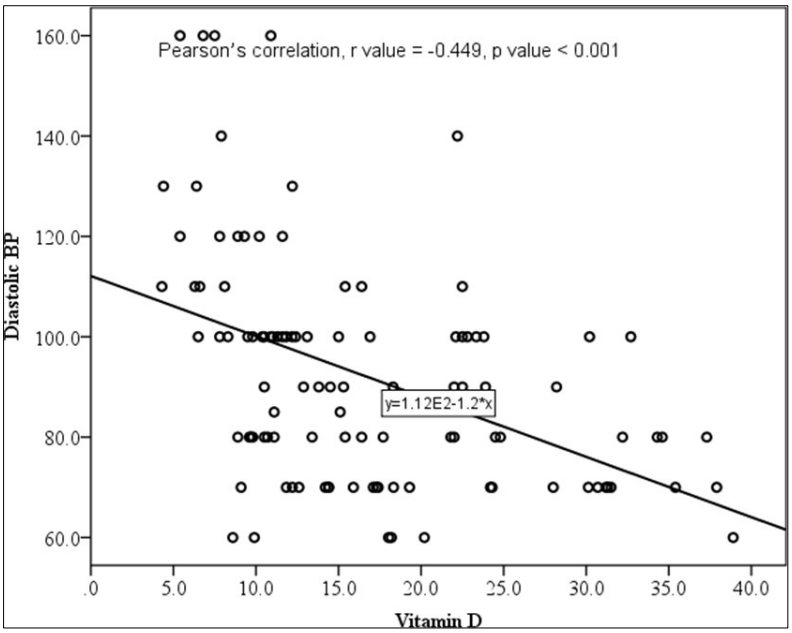

Figure 2: Scatter diagram showing correlation and regression between vitamin D and diastolic blood pressure (DBP)

There was a negative correlation (r = -0.449) observed between maternal vitamin D and diastolic blood pressure, which was statistically significant ($p<0.05$). The linear regression equation was y = 112 – 1.2*x, i.e. one unit of vitamin D was increased, and diastolic blood pressure was decreased 1.2 times.

DISCUSSION

The present study demonstrated a significant inverse correlation between maternal serum vitamin D levels and both systolic and diastolic blood pressure in late pregnancy. Women with lower 25-hydroxyvitamin D concentrations tended to exhibit higher blood pressure readings, independent of age, body mass index, and gestational age. This finding supports accumulating evidence that vitamin D deficiency is not only a nutritional concern but also a potential contributor to hypertensive changes in pregnancy.

The observed negative correlation (r = –0.449 for both systolic and diastolic pressures) aligns with previous research reporting similar inverse associations between serum 25(OH)D and blood pressure measurements in pregnancy. For instance, Meenakshi and Arshiya found that pregnant women with vitamin D insufficiency exhibited higher systolic and diastolic pressures than those with sufficient levels, suggesting that sub-optimal vitamin D status may compromise vascular regulation during gestation [11]. Singla *et al.*, found comparable results in an Indian cohort, where serum vitamin D levels were inversely correlated with both systolic and diastolic components, suggesting that deficiency may impair vascular compliance [8]. Likewise, Iurciuc *et al.*, demonstrated that lower serum 25-hydroxyvitamin D levels were associated with increased arterial stiffness—as measured by pulse-wave velocity—among pregnant women with hypertensive disorders, suggesting a plausible mechanism linking vitamin D deficiency and vascular dysfunction in pregnancy [12]. These findings collectively support the hypothesis that adequate vitamin D levels help maintain vascular elasticity and endothelial function.

The physiological basis for this association can be explained through several mechanisms. Vitamin D directly suppresses renin gene expression, thereby modulating the renin–angiotensin–aldosterone system (RAAS), a key regulator of blood pressure [2]. Experimental studies have shown that 1,25-dihydroxyvitamin D_3 inhibits renin synthesis, leading to lower angiotensin II and aldosterone production [13]. In vitamin D deficiency, this inhibitory effect is diminished, resulting in upregulation of the RAAS pathway and subsequent vasoconstriction, sodium retention, and elevated blood pressure. Additionally, vitamin D contributes to vascular health through its anti-inflammatory and antioxidative properties. It reduces the expression of proinflammatory cytokines such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), while enhancing endothelial nitric oxide synthesis, which promotes vasodilation [7]. These biological actions may explain the observed negative relationship between vitamin D status and blood pressure levels in pregnant women.

The results of this study also highlight the potential influence of behavioral factors, particularly sun exposure and clothing practices, on vitamin D synthesis. Although average sun exposure duration did not differ significantly between groups, a higher prevalence of full-body covering (veil or burqa use) among preeclamptic women may have limited cutaneous vitamin D

production despite adequate sunlight availability. Similar patterns have been reported in Middle Eastern and South Asian populations. Al-Turki *et al.*, (2008) found that women who wore conservative clothing had significantly lower serum vitamin D concentrations and higher mean blood pressures [14]. These cultural determinants of sunlight exposure must therefore be considered when addressing vitamin D deficiency as a modifiable cardiovascular risk factor.

The relationship between vitamin D and blood pressure observed in this study extends beyond pregnancy and mirrors findings in the general population. Pilz *et al.*, and Kunutsor *et al.*, documented that individual with lower vitamin D levels had higher systolic and diastolic pressures and increased risk of hypertension [15,16]. However, pregnancy is a unique physiological state in which the maternal cardiovascular system undergoes profound hemodynamic adaptation. Vitamin D deficiency may disrupt these adaptive responses, resulting in increased vascular resistance and abnormal placental perfusion. Consequently, maintaining adequate vitamin D levels during pregnancy may help stabilize blood pressure and potentially prevent progression to hypertensive disorders such as preeclampsia.

The regression analysis in this study indicated that for every 1 ng/mL increase in serum vitamin D concentration, systolic blood pressure decreased by approximately 1.68 mmHg and diastolic pressure by 1.2 mmHg. These findings are consistent with the results of Ullah *et al.*, who reported that each incremental rise in vitamin D reduced systolic blood pressure by 1.6 mmHg among Bangladeshi pregnant women [10]. Although the magnitude of change may appear modest, on a population scale, such reductions are clinically meaningful and could translate into lower rates of hypertensive complications.

Contrary to some studies, this analysis did not find significant differences in mean BMI or gestational age between groups, suggesting that the relationship between vitamin D and blood pressure operates independently of these confounders. Nevertheless, the absence of dietary vitamin D assessment and seasonal variation data limits further exploration of these associations.

In summary, the findings reinforce the role of vitamin D as an important physiological determinant of vascular health during pregnancy. Regular antenatal surveillance, nutritional screening, and awareness of sunlight exposure practices are critical to maintaining optimal maternal vitamin D status. Randomized controlled trials are needed to determine whether vitamin D supplementation can effectively reduce blood pressure levels and prevent hypertensive complications in pregnancy.

Limitations of the study

- The case–control design limits causal inference between vitamin D levels and blood pressure.
- The sample size was modest, and seasonal variation, dietary intake, physical activity, and genetic factors were not assessed.
- Although sun exposure duration was recorded, UVB intensity and body surface exposure were not quantified, which may have introduced residual confounding.

CONCLUSION

This study revealed a significant inverse correlation between maternal serum vitamin D concentrations and blood pressure components in pregnancy. Each unit increase in vitamin D was associated with a measurable reduction in both systolic and diastolic blood pressure. These results underscore the potential role of vitamin D in maintaining vascular health and preventing hypertensive complications during pregnancy. Regular monitoring of vitamin D status, nutritional counseling, and appropriate supplementation should be considered as part of antenatal care, especially in populations with prevalent deficiency.

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Conflicts of Interest: There are no conflicts of interest.

Ethical Approval: The study was approved by the Institutional Ethics Committee.

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