Prevalence and Seasonal Variations of Vitamin D Deficiency in the Southeastern Region of Bangladesh

Mahjabin Nobi Khan, Muhammad Farhan Muhtasim, Abdullah Al Persi, Md. Ajijul Hoq, Noor-E-Amrin Alim, Mohammad Sazzad Hossain, Anjuman Ara Akhter, Pabitra Kumar Bhattacharjee

Institute of Nuclear Medicine and Allied Sciences (INMAS), Chattogram

Correspondence Address : Mahjabin Nobi Khan, Scientific Officer, INMAS, Chattogram, CMCH campus E-mail: mahjabin.nobi.khan@gmail.com

ABSTRACT

Background: Vitamin D deficiency due to varying sunlight exposure in adult population is one of the prevalent medical conditions worldwide.

Objectives: To investigate the prevalence of and the seasonal influence on vitamin D deficiency among the people residing in the Chattogram division of Bangladesh.

Methods: The serum 25-hydroxy vitamin D (25-OHD) was assessed by the chemiluminescence method. To investigate the seasonal impact three distinct seasons were broadly categorized winter, summer, and rainy seasons.

Results: This observational study analyzed serum 25-OHD data from 969 participants, comprising 777 adults (80%) and 192 children (20%). Among the adults, 77% were female and 23% male, while in the child group, 53% were female and 47% male. A significant positive correlation was found between age and serum 25-OHD (p=.001**). Comparison based on gender, adult males showed relatively higher mean serum 25-OHD levels (18.79 ± 11.02 ng/mL) than females (16.69 ± 10.16 ng/mL). The varying degrees of vitamin D deficiency (mild, moderate, severe) were significantly associated with the gender of the adult participants (X2 (2, N = 712) =5.994, p = 0.05*) as well. Seasonal comparison in women showed a better status of vitamin D3 (significantly higher, mean difference: 2.16, p = 0.047*) in the rainy season than winter.

Conclusion: The highest average serum vitamin D3 levels were observed during the rainy season, while the lowest occurred in winter, with significant seasonal variation in 25-OHD levels found only in females. This suggests that seasons may influence vitamin D deficiency status.

Keywords: 25-hydroxy vitamin D, chemiluminescence immune assay, seasonal variation, gender difference

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INTRODUCTION

Vitamin D is one of the necessary micronutrients the human body needs for the growth and development of bones. It is an essential micronutrient, which impacts non-skeletal organs like the brain, heart, prostate, colon, and immune cells also. Deficiency causes impaired neuromuscular functions and requires inactive precursors from plant and animal sources (1, 9). It is an essential micronutrient because the body itself cannot produce vitamin D. Therefore, inactive precursors of vitamin D, such as vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol), must be provided from plant and animal sources. Moreover, in the presence of UV radiation with a wavelength of 290-315 nm of sunlight, these inactive precursors turn to the biologically active form of 1, 25-dihydroxy vitamin D (2, 8). Apart from seasons and duration of UV exposure, various geographical factors, including solar elevation, ozone, cloudiness, etc., as well as human factors such as age, gender, dietary intake of vitamin D, skin pigmentation, and outdoor activity habits, play a crucial role in vitamin D production (3-4). Approximately 1 billion people experience vitamin D deficiency or insufficiency, highlighting its status as one of the most prevalent medical conditions worldwide (5).

Vitamin D deficiency is relatively prevalent in Asia (8). Bangladesh, like other South Asian countries, is not exempt from the widespread prevalence of vitamin D deficiency among the general population (5-6). While the influence of seasonal variations on serum 1, 25-dihydroxy vitamin D has been extensively documented in previous research, studies examining the seasonal effects on vitamin D levels among populations residing in the southeastern region of Bangladesh remain limited.

Bangladesh experiences a diverse subtropical climate, marked by a prominent monsoon season and heightened vulnerability to extreme weather events, particularly in the summer. The Bay of Bengal in the south, the Himalayas in the north, and the major river systems influence the weather of this country significantly (7). As sunlight exposure plays a critical role in vitamin D synthesis, it is reasonable to hypothesize that the varied subtropical climate of Bangladesh is likely to influence the vitamin D status of its population (9, 10).

The study aimed to investigate the prevalence of vitamin D deficiency among children and adults residing in the southeastern region of Bangladesh. Another focus of this study was to find whether the seasons influence the occurrence of vitamin D deficiency.

PATIENTS AND METHODS

Subjects and data collection

This observational study included serum 1, 25-dihydroxy vitamin D data of 969 participants, referred to the institute for their vitamin D measurement. Most of these patients, referred by specialist physicians, reported concerns related to osteoporosis symptoms and other medical conditions. The data was collected over the period of January 2021 to December 2023 (36 months).

Laboratory measurements

25-hydroxy vitamin D (25-OHD) was assessed from the serum sample by the chemiluminescence immune assay (CLIA) method using the ADVIA Centaur® XPT Immunoassay System.

Definitions of vitamin D deficiency and seasonal analysis: Depending on the values of 25-OHD, different definitions of vitamin D deficiency were considered in this study. Mild, moderate, and severe vitamin D deficiency was defined as 25-OHD values of 20 to <30 ng/mL, 10 to <20 ng/mL, and <10 ng/mL respectively. Moderate and severe categories were considered as vitamin D deficiency, likewise mild as vitamin D insufficiency.

Based on the months three distinct seasons were broadly categorized to investigate the seasonal impact on vitamin D deficiency (11).

Table 1. Seasonal classification, based on months

Seasons	Months
Winter	November, December, January and February
Summer	March, April and May
Rainy	June, July, August, September and October

Statistical analysis

Continuous variables were calculated by mean ± standard deviation. The Pearson Correlation Coefficient was used to assess the association between continuous variables (two-tailed). A one-way ANOVA (Analysis of Variance) was performed to compare vitamin D levels between seasonal groups. After that, a Post-Hoc test was applied in pairwise comparisons. For all of the tests, $p \leq 0.05$ were considered statistically significant. Statistical analysis and data presentation were performed using MS Excel and IBM SPSS version 20 software.

RESULT

The serum vitamin D levels were normally distributed for the entire cohort of 969 participants with a mean value of 17.26±11.71 ng/mL. Out of 969 participants, 888 (92%) exhibited varying degrees of vitamin D deficiency, while 81 (8%) had normal serum vitamin D levels. This entire cohort included 777 (80%) adult (age ≥ 18 years) and 192 (20%) child (age < 18 years) participants. The average ages of adult and child participants were 41.06± 14.21 years and 7.92± 5.22 years. The key characteristics and the prevalence of vitamin D deficiency of the study participants are summarized in Table 2 and 3 respectively below.

Table 2: Characteristics of the study participants.

Participants	Gender	Age (years)	Average Age ± SD (years)	Frequency (%)
Child (192, 20%)	Male	0.5 to 17 years	7.14± 4.99	91 (47%)
	Female		8.62± 5.35	101 (53%)
Adult (777, 80%)	Male	18 to 80 years	43.64± 14.40	181 (23%)
	Female		40.28± 14.11	596 (77%)

Table 3. Vitamin D deficiency status in different groups of participants

Participants	Vitamin D deficiency	Frequency	Prevalence rate (%)
	Severe	50	26.04
	Moderate	98	51.04
	Mild	28	14.58
Child (192, 20%)			
	Deficiency	148	77.08
	Insufficiency	28	14.58
	Normal	16	8.33
	Severe	164	21.11
	Moderate	397	51.09
	Mild	151	19.43
Adult (777, 80%)			
	Deficiency	561	72.21
	Insufficiency	151	19.43
	Normal	65	8.37

While analyzing the correlation between age and serum concentration of vitamin D of all the study participants, a significant positive correlation was found (p = .000**, r = .174**, correlation is significant at the 0.01 level). The mean concentrations of serum 25-OHD were higher in male participants (18.79 ± 11.02 ng/mL) than in females (16.69 ± 10.16 ng/mL). Especially in the case of adult vitamin D-deficient participants, an independent sample t-test was conducted to evaluate whether there was a significant difference in vitamin D concentration between the male and female participants. The test showed that the mean vitamin D concentration is significantly higher in males (15.91 ± 6.07 ng/mL) than in females (14.49 ± 5.78 ng/mL), with a mean difference of 1.42 (95% CI, .39 to 2.45) gm/cm², t (712) = 2.72, p = .007**.

The relationship between the gender of the adult participants and varying degrees of vitamin D deficiency, classified as mild, moderate, and severe, was examined. From Pearson's Chi Squared test, the varying degrees of vitamin D deficiency were found significantly associated with the gender of the adult participants (X2 (2, N = 712) = 5.994, p = 0.05*).

Data was gathered each month to assess the effect of seasons on vitamin D deficiency patterns. The highest frequency of vitamin D deficiency was observed in February (prevalence rate is 14.53%), corresponding to the winter season. However, the data showed the highest prevalence rate in the rainy season. The prevalence rates of Vitamin D deficiency in different months are shown in Table 4.

Table 4: All study participants' seasonal status of Vitamin D deficiency.

Seasons	Months	Vitamin D Deficiency Status (%)		Average Concentration of serum vitamin D (ng/mL)
	November	7.05		16.36
Winter	December	8.89	35.54	14.15
	January	5.08		19.19
	February	14.53		16.77
	March	12.55		17.35
Summer	April	5.64	25.11	17.24
	May	6.91		
	June	7.33		17.18
	July	8.18		15.75
Rainy	August	7.48	39.35	18.65
	September	11.00		16.89
	October	5.36		22.07

The highest and lowest average concentrations of serum vitamin D were found in the month of October (22.07 ± 11.7 ng/mL) and December (14.17 ± 11.4 ng/mL) which correspond to the rainy and winter season respectively. Comparison of vitamin D levels, found in three different seasons in case of only female participants showed that vitamin D status was better (significantly higher, mean difference: 2.16, $p = 0.047^*$) in rainy season than in winter.

DISCUSSION

Vitamin D is a crucial fat-soluble nutrient that plays a key role in maintaining calcium balance, supporting bone health, and reducing the risk of falls and fractures. Additionally, it has been linked to various common public health conditions such as hypertension, metabolic syndromes, cancers, etc. (17, 18). The prevalence of vitamin D deficiency and insufficiency in the adult and child populations in Bangladesh is very common. A study including different groups of the population of this country showed that hypovitaminosis D ranged from 38 to 100 percent for premenopausal women, 6 to 91.3% for adult men, and 82 to 95.8% for postmenopausal women (12). Another study found that on average almost 80% of Bangladeshi children are vitamin D deficient (13). Similarly, this analysis, conducted among individuals residing in the southeastern region of Bangladesh, revealed that approximately 72.2% of adults and 77.1% of children exhibit vitamin D deficiency. In comparison, 19.4% of adults and 14.6% of children have insufficient levels of vitamin D. Conversely, only 8.4% of adults and 8.3% of children were found to have normal serum levels of vitamin D.

Numerous systematic reviews have reported a high global prevalence of vitamin D deficiency, including in regions with low latitudes, where it was traditionally assumed that adequate levels of ultraviolet B (UVB) radiation would suffice to prevent such deficiencies (17, 19). Bangladesh lies between 20°34' and 26°38' north latitude, including Chattogram with 22.3752° N, 91.8349° E. Though it corresponds to low-latitude regions, people residing in this area showed a high prevalence of deficiency and insufficiency of vitamin D. However, for individuals living in the southeastern region of this country, factors such as lifestyle, lack of awareness, and religious practices may contribute to the high prevalence of vitamin D deficiency and insufficiency in this area. Since the main source of vitamin D is exposure to ultraviolet B (UV-B) radiation from the sun, diet serves as the secondary source of vitamin D. Food, including fatty fish, eggs, and milk, being the dietary sources of 25-OHD. However, a lack of awareness and nutritional knowledge often leads to widespread vitamin D deficiency among individuals (16). As a result, a substantial proportion of the general population is at risk of vitamin D deficiency due to intermittent and irregular exposure to sunlight, coupled with inconsistent dietary intake. To evaluate the seasonal influence on vitamin D deficiency, the cases were stratified according to the months of the year. In this study, the twelve months of the year were categorized into three primary seasons: winter, summer, and rainy. The highest serum vitamin D concentration was observed in October, while the lowest concentration was recorded in December, representing the rainy and winter seasons, respectively, based on the seasonal classifications. Similar findings were recently found in other studies. One showed that the average 25-OHD levels were highest in September, measuring 24.1 ± 6.9 ng/ml, and lowest in January, with a level of 15.5 ± 5.9 ng/ml (14). Another study including older residents of long-term care facilities showed that the mean 25-OHD level in the March sample (39.9 ± 19.7 nmol/L) was significantly lower than the mean 25-OHD level in the September sample (44.9 ± 16.9 nmol/L) (15). An additional analysis found that there was a seasonal variation in both 25-D and 1,25-D serum concentrations. 25-D levels were lowest in January and increased until July, while the nadir and zenith of 1,25-D were found in April and October, respectively (20). While comparing the serum level of 25-OHD of all the female participants among seasons, it was found to be significantly higher in the rainy than the winter season.

This study also identified a significant positive correlation between age and serum 25-OHD concentration in adult participants, with serum 25-OHD levels increasing as age increased. Similar results were reported in other investigations also (1, 20, 21). Gender-based analysis showed a significantly higher level of serum 25-OHD in males than females, which is also similarly found in other research (20, 21). Older individuals, particularly those in retirement, may have increased opportunities for outdoor activities (22). Additionally, older individuals are often more frequently monitored for health issues, leading to regular vitamin D assessments and timely interventions, such as supplementation. Coupled with the greater availability and accessibility of vitamin D supplements in the market, these factors can help maintain or elevate serum vitamin D levels.

CONCLUSION

The study found seasonal changes in Bangladesh's southeastern region significantly impact vitamin D deficiency status. Factors like age, sex, dietary habits, occupation, and religious practices could also affect 25-OHD levels.

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