Vitamin D Status and its Associated Risk Factors in Apparently Healthy Bangladeshi Adults

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Abstract

Background:
Though Vitamin D deficiency (VDD) is highly prevalent worldwide, there is very limited data in Bangladesh.

Objective:
The aim of this study was to determine the vitamin D status and its associated risk factors in apparently healthy Bangladeshi adults.

Methods:
This observational cross-sectional study was carried out in 232 apparently healthy adult participants, who visited the hospital as an attendant of the patients from the Department of Endocrinology, Bangabandhu Sheikh Mujib Medical University (BSMMU). All the participants were taken their demographic profile and investigated for vitamin D levels. High-performance liquid chromatography (HPLC) was used to measure Serum 25(OH)D.

Results:
About 30% of healthy individuals had VDD with a cut-off of vitamin D level <12 ng/ml, followed by around 40% who had vitamin D insufficiency and another 30% who had vitamin D sufficiency. People with age ≥60 years had significantly higher vitamin D levels (ng/ml) than people with age 40 – 59 years [21.14±10.19 vs. 15.31±7.40, post hoc Tukey test p=0.015]. Inadequate exposure of body surface area (<20%) to sunlight was significantly associated with higher VDD category [90.1% vs. 9.9%, p=0.027] and lower vitamin D level [15.84±7.67 vs. 19.03±6.98, p=0.014] than individuals with adequate exposure. Inadequate exposure to sunlight was associated with 3.197 (0.073, 9.532) times increased risk of VDD (p=0.037).

Conclusion:
Around one-third apparently healthy Bangladeshi adults had VDD that might be contributed by inadequate exposure of body surface area to sunlight.

Keywords: Vitamin D, Vitamin D deficiency, Risk factor, Bangladeshi adults

Introduction:

Vitamin D has a crucial role in calcium homeostasis and metabolism in the human body and consequently is considered important to maintain bone health.[1] Vitamin D plays an essential role in the modulation of the immune system and the regulation of body cells' differentiation and proliferation. Therefore, vitamin D deficiency (VDD) is believed to be associated with the risk of several serious non-skeletal chronic diseases such as autoimmune diseases, cardiovascular disease, and certain cancers.[2] Almost 90% of the human endogenous vitamin D is synthesized primarily in the skin by activation of 7-dehydrocholesterol triggered by exposure to ultraviolet (UVB) sunlight, so limited exposure to the sunlight might lead to VDD. The remaining 10% is acquired from nutritional sources such as codfish, mushrooms, eggs, and fortified foods including milk. Although vitamin D synthesis depends on UVB sunlight exposure, many other factors such as age, obesity, skin color, dress style, and sunscreen use might affect vitamin D level.[3] Currently, the global prevalence of VDD is an epidemic and considered a public health concern in many regions around the world.[4] In Bangladesh, several recent studies have reported that about 82% to 100% of the studied Bangladeshi populations have low (insufficient or deficient) vitamin D

levels.[5-10] A study conducted within the working population found that 100% of the garments workers and the seemingly healthy population and 94.3% of Bangladeshi adult Muslim females had vitamin D levels lower than normal.[7,8] Despite having abundant exposure to the sun, about 71% of healthy coastal fishermen had low vitamin D.[10] A recent Bangladeshi study also found VDD in about 87.3% of new type 2 diabetes mellitus and 74.5% of healthy control. Several factors could contribute to VDD. Therefore, it is important to determine the risk factors that are associated with VDD in order to establish relevant strategies to prevent and manage this emerging health problem. Few studies have examined the vitamin D status and its associated factors of healthy adults from Bangladesh. Therefore the aim of this study was to assess vitamin D status in healthy Bangladeshi adults and identify the major risk factors which might be associated with VDD by evaluating selected variables related to socio-demographic, lifestyle, and health status characteristics, as well as, dietary intake.

Methods:

This Observational cross-sectional study was conducted in the Department of Endocrinology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka. Adult attendants of patients of BSMMU were requested to participate in the study. Participants who were taking or had received vitamin D or calcium supplements within the last 120 days of sample collection, or took medication that affected calcium, vitamin D metabolism, and bone, or who had any known diseases were excluded from the study. The willing participants underwent full clinical assessment, prior to enrollment it was established that all of the participants had normal liver and kidney function. A total of 232 apparently healthy adult attendants of patients of BSMMU were recruited during the period of January 2018 to January 2019. Anthropometric measurements were performed using the same standardized techniques and calibrated digital scale (Seca, Germany), throughout the study. Body mass index (BMI) was calculated, for all subjects wearing light clothing and no shoes, as weight in kilograms (kg) divided by squared height in meters (m). Dietary intake of calcium and vitamin D was collected from 7-day food diaries. Physical activity information was obtained by the International physical activity questionnaire (Short last 7 days self-administered format).[11] Sunlight exposure was evaluated based on sunscreen use and daily average time of sun exposure between 11:00 to 15:00 hour with the sun exposure >20 % body surface.[12] A morning fasting 10 ml venous blood sample was collected from each subject. The sample tubes were covered by aluminum foil paper and complete centrifugation of the blood sample was done in a dark room and serum was separated. Serum was collected in tubes and preserved at – 20^{0}C until assay. Serum sample for 25(OH)D was transported to Centre for Advanced Research in Sciences, Dhaka University. All the samples were analyzed by the same methods throughout the study period, using kits provided by the same manufacturer. 25(OH)D was measured by High-performance liquid chromatography (SIL 20 series prominence HPLC, Shimadzu, Japan). The manufacturer's normal range as re ported in the kit was 20 to 100 ng/ml with an analytical sensitivity of 2.0ng/ml. The coefficient of variability was 2.6 – 4.9%. Data was cross-checked daily at the end of the day to find out errors and inconsistency of data and necessary editing, cleaning, coding, and tabulation was done manually.

Operational definition:

Vitamin D status was categorized by the Institute of Medicine (IOM), 2011 criteria into vitamin D sufficiency (20 ng/ml or 50 nmol/L), insufficiency (12–19.99 ng/ml or 30-50 nmol/L), and the deficiency (<12 ng/ml or 30 nmol/L).[13]

Statistical analysis:

Data were analyzed using a computer-based SPSS program (version 22.0). Analyzed data were described in frequencies (percentages) for qualitative values and mean (SD) for quantitative values. Comparison between groups was done by independent-samples T-test or one-way ANOVA test (with post hoc Tukey test) for quantitative variables and Pearson's chi-square/ Fisher's exact test for qualitative variables. Correlations of vitamin D with clinical variables were done by Pearson's correlation test. Multivariate linear regression analysis was done with vitamin D level as the dependent variable. Multivariate multinomial logistic regression analysis was done to see the predictive associations of sociodemographic and vitamin D-related factors with VDD. A two-sided p <0.05 was set as statistically significant.

Results:

Figure-1 showed the vitamin D status of the study

population according to IOM criteria. Around 30% of healthy individuals had VDD with a cut-off of vitamin D level <12 ng/ml, followed by around 40% who had vitamin D insufficiency (12–19.99 ng/ml) and another 30% had vitamin D sufficiency (20 ng/ml).

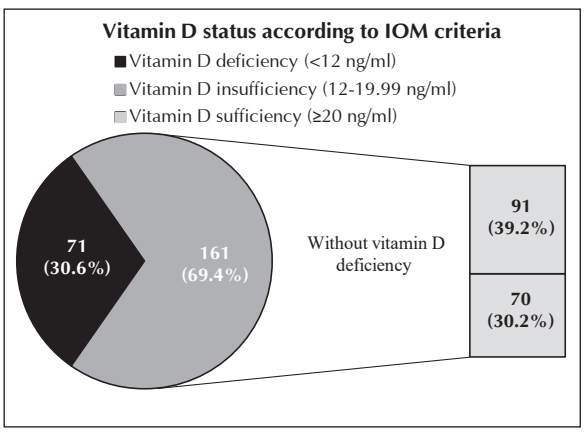


Figure-1: Vitamin D status of the study population according to IOM criteria

Table-II showed vitamin D level and status according to some vitamin D related factors including physical findings. None of them except inadequate exposure of body surface area (<20%) to direct sunlight was significantly associated with higher VDD category [90.1%vs. 9.9%, p=0.027] and lower vitamin D level [15.84±7.67 vs. 19.03±6.98, p=0.014] than individuals with adequate exposure of body surface area to sunlight.

None of the variables were significantly correlated with vitamin D (age: r= 0.080, p= 0.227; BMI: r= 0.001, p= 0.990; WC: r= -0.097, p= 0.139; SBP: r= 0.047, p= 0.476). Similarly, none of the variables had significant predictive associations with vitamin D level (age: β= 0.071, p= 0.297; BMI: β= 0.078, p= 0.338; WC: β= 0.143, p= 0.080; SBP: β = -0.029, p=0.772; DBP: β= 0.087, p= 0.383; constant: B= 17.688, p= 0.002) in linear regression analysis.

Table-I: Associations of vitamin D with demographic characteristics of the study population

Variable	Categories	Number (%)	Vitamin D			*p-value	Vitamin D level (ng/ml)	**p-value
			Deficiency	Insufficiency	Sufficiency			
			71(30.6%)	91(39.2%)	70(30.2%)		mean±SD	
Age group (Years)	<40	141(60.8)	43(60.6)	56(61.5)	42(60.0)		16.47±7.27	
	40-59	75(32.3)	25(35.2)	30(33.0)	20(28.6)	0.519	15.31±7.40	0.021
	≥60	16(6.9)	3(4.2)	5(5.5)	8(11.4)		21.14±10.19	
Sex	Male	111(47.8)	32(45.1)	44(48.4)	35(50.0)	0.842	16.36±7.49	0.917
	Female	121(52.2)	39(54.9)	47(51.6)	35(50.0)		16.47±7.80	
Resident‡	Rural	45(19.4)	10(14.1)	20(22.0)	15(21.4)	0.401	17.60±7.72	0.250
	Urban	187(80.6)	61(85.9)	71(78.0)	55(78.6)		16.13±7.61	
Educational status	Not completed primary	36(15.5)	9(12.7)	15(16.5)	12(17.1)		18.11±8.06	
	Not completed secondary	79(34.1)	20(28.2)	33(36.3)	26(37.1)	0.53	17.19±7.65	0.106
	Not completed graduation	43(18.5)	19(26.8)	14(15.4)	10(14.3)		14.30±7.44	
	Completed graduation	74(31.9)	23(32.4)	29(31.9)	22(31.4)		16.00±7.36	
Socio-economic status¶	High	28(12.1)	8(11.3)	12(13.2)	8(11.4)		16.26±5.52	
	Middle	123(53.0)	37(52.1)	49(53.8)	37(52.9)	0.988	16.51±7.76	0.975
	Low	81(34.9)	26(36.6)	30(33.0)	25(35.7)		16.29±7.86	
Smoking status†	Nonsmoker	174(75.0)	52(73.2)	68(74.7)	54(77.1)	0.876	16.48±8.26	0.835
	Smoker (current/past)	58(25.0)	19(26.8)	23(25.3)	16(22.9)		16.23±8.26	
Physical activity level	High	69(29.7)	17(23.9)	33(36.3)	19(27.1)		17.17±7.82	
	Medium	128(55.2)	45(63.4)	49(53.8)	34(48.6)	0.059	15.48±7.34	0.088
	Low	35(15.1)	9(12.7)	9(9.9)	17(24.3)		18.36±8.01	

* Pearson's chi-square/Fisher's exact test was done as appropriate;
** Independent samples-T test/one way ANOVA (with post hoc Tukey) test was done as appropriate.
‡ Bangladesh national conservation strategy, 2013[14]
¶ Socio-economic status by monthly income[7]
† Mayo clinic smoking status category[15]

Table-II. Associations of vitamin D with vitamin D related factors and physical findings

Variable	Categories	Number (%)	Vitamin D			*p-value	Vitamin D, ng/ml (mean±SD)	**p-value
			Deficiency	Insufficiency	Sufficiency			
Sunlight exposure time	Adequate	103(44.4)	30(42.3)	40(44.0)	33(47.1)	0.853	17.02±7.85	0.284
	Inadequate	129(55.6)	41(57.7)	51(56.0)	37(52.9)		15.94±7.46	
Body surface area exposed to sunlight	Adequate	42(18.1)	7(9.9)	16(17.6)	19(27.1)	0.027	19.03±6.98	0.014
	Inadequate	190(81.9)	64(90.1)	75(82.4)	51(72.9)		15.84±7.67	
Use of sunscreen lotion (SPF >8)¶	Yes	16(6.9)	8(11.3)	4(4.4)	4(5.7)	0.266	13.93±6.84	0.178
	No	216(93.1)	63(88.7)	87(95.6)	66(94.3)		16.60±7.67	
Consumption of vitamin D containing food¥	Yes	189(81.5)	61(85.9)	70(76.9)	58(82.9)	0.330	16.32±7.97	0.704
	No	43(18.5)	10(14.1)	21(23.1)	12(17.1)		16.82±6.00	
Body mass index, Kg/m^2 ǂ	Obese (≥27.5)	39(16.8)	12(16.9)	16(17.6)	11(15.7)	0.920	16.08±6.74	0.933
	Overweight (23–27.4)	117 (50.4)	34(47.9)	48(52.7)	35(50.0)		16.74±7.50	
	Optimal (18.5 – 23)	70(30.2)	23(32.4)	26(28.6)	21(30.0)		16.52±6.38	
	Underweight (<18.5)	6(2.6)	2(2.8)	1(1.1)	3(4.3)		16.06±8.51	
Waist circumference, cm	Centrally nonobese	130(56.0)	43(60.6)	51(56.0)	36(51.4)	0.560	15.88±7.32	0.225
	Centrallyobese (M≥90, F≥80)	102(44.0)	28(39.4)	40(44.0)	34(48.6)		17.10±8.00	
Blood pressure, mm-Hg	Normotensive	42(18.1)	12(16.9)	16(17.6)	14(20.0)	0.909	17.74±7.24	0.214
	Hypertensive (≥140/90)	190(81.9)	59(83.1)	75(82.4)	56(80.0)		16.12±7.71	

*Pearson's chi-square/Fisher's exact test was done appropriately;
**Independent samples T-test/one way ANOVA test was done as appropriate
¶ SPF (sun protecting factor)[16]
¥Sunlight exposure of >20% of body surface area (face, arms, hands & legs)
ǂ At least 1 serving of egg yolk or large fish per day, at least 4 days a week (Micka)[17]
ǂ BMI classification for Asian[18]

Multinomial multivariate logistic regression analysis showed that inadequate exposure to sunlight was associated 3.197 times increased risk of VDD. None of the other variables had a significant predictive association with VDD [Table-III].

Table-III: Multivariate multinomial logistic regression of vitamin D deficiency (<12 ng/ml) as the dependent variable

Variable	Categories	OR (95%CI)	p-value
Age group (Years)	<40	1	
	40-59	1.100(0.529, 2.286)	0.818
	60	0.683(0.134, 3.490)	0.406
Sex	Male	1	
	Female	0.864(0.336, 2.221)	0.803
Resident	Rural	1	
	Urban	2.396(0.884, 6.496)	0.165
Educational status	Not completed primary	1	
	Not completed secondary	0.443(0.099, 1.990)	0.261
	Not completed graduation	0.497(0.158 1.560)	0.492
	Completed graduation	1.609(0.581, 4.458)	0.675
Socio-economic status	High	1	
	Middle	1.854(0.451, 7.621)	0.523
	Low	3.661(0.708, 18.931)	0.195
Physical activity level	High	1	
	Medium	1.541(0.729, 3.259)	0.181
	Low	0.759(0.199, 2.894)	0.933
Smoking status	Nonsmoker	1	
	Smoker	0.946(0.399, 2.241)	0.918
Sunlight exposure time	Adequate	1	
	Inadequate	1.418(0.666, 3.021)	0.365
Body surface are exposed to sunlight	Adequate	1	
	Inadequate	3.197(0.073, 9.532)	0.037
Use of sunscreen lotion	No	1	
	Yes	2.254(0.669, 7.596)	0.190
Consumption of vitamin D containing food	No	1	
	Yes	0.566(0.249, 1.289)	0.175
BMI	Optimal	1	
	Underw eight	2.086(0.295, 14.768)	0.462
	Overweight	0.878(0.415, 1.859)	0.735
	Obese	0.922(0.323, 2.630)	0.880
Waist circumference	Nonobese	1	
	Centrally obese	1.244(0.574, 2.697)	0.579
Blood pressure	Normotensive	1	
	Hypertensive	0.977(0.430, 2.222)	0.957
Intercept		B= -2.203	0.015

OR= odds ratio; CI= confidence interval; B= unstandardized regression co-efficient

Discussion:

The present study found that higher proportion of vitamin D insufficiency (40%) and relatively low VDD (30%) in healthy Bangladeshi adults according to IOM criteria. People with older age (60 years) had significantly higher vitamin D levels than people with age group 40 – 59 years. Only inadequate exposure of body surface area to

sunlight was significantly associated with higher VDD category and lower vitamin D than individuals with adequate exposure of body surface area to sunlight. None of the other variables (gender, locality, income level, physical activity, sun exposure, dietary history, obesity) had any associations with either vitamin D status or level. In this study, we found that VDD was relatively low in healthy Bangladeshi adults. Similar results greatly influences vitamin D status. Almost all previous research works in our country have found a higher frequency of VDD than our finding.[5-10] Also, a high prevalence of VDD has been reported among healthy adults from tropical and subtropical regions in India and other South Asian countries, where there is equally sufficient sunshine compared to our study[21-23]. An overall pooled estimate of results from many European countries, irrespective of age group, ethnic mix, and latitude of study populations, showed a VDD of 40.4% which is far much higher than that observed in our study.[24] All of these observations may probably reflect the impact of lifestyle and environmental factors on vitamin D status. The use of different cut-off values (<12 ng/ml) to define VDD might be an important cause of this different result.The highest percentage of deficient vitamin D levels was found in 40 – 59 years of age group than age 60 years in our study. The result is somewhat unexpected since an inverse association between 25OHD and age has been shown in several previous large population-based studies.[19,25,26] Our active working-age groups are suffering from low vitamin D levels possibly due to lifestyle and behavioral changes across generations, such as a tendency to work indoors and avoidance of sunlight exposure in the younger generation as compared to prior generations. The use of multivitamins and vitamin D supplementation has increased in our older adults than a young adult that might play another role. However, there were also studies showing that the younger age group had a lower serum 25(OH)D level compared to older subjects.[7,20] Sunlight exposure plays a vital role in VDD and only 1 – 2 hours/day of sun exposure is sufficient for normal vitamin D3 level.[8] Our study revealed that vitamin D status was not influenced by sunlight exposure but inadequate exposure of body surface area of skin to sunlight correlated with VDD. Similar findings were found in a study in which those who covered their body less (<60%) had more VDD.[20] It could be probably due to the climatic and cultural conditions that warrant more body covering for those who spent more time outdoors than when indoors. Most of the participants did not own cars, thus they eventually at some point of the day had to walk out, either to take a cab or walk home, leading to some degree of outdoor sun exposure. Association of VDD and inadequate exposure of body surface area of skin to sunlight may indicate not only sunlight exposure, but the exposure of body surface area is an important factor for vitamin D status in our population. Contrarily, a study in the United Arab Emirates reported low vitamin D levels with increased Sun Avoidance Inventory score (which includes outdoor activities and dressing style), highlighting the effect of exposure to sun on vitamin D.[27] This study revealed no significant difference in vitamin D status between females and males which is in conformity with the results of a systematic review of vitamin D status in populations worldwide which did not reveal any substantial gender-related differences in vitamin D status. Contrarily, another study found that females had significantly higher vitamin D levels than males. The locality of urbanization may not have had any effect on vitamin D in this study; which is contrary to another two Bangladeshi studies.[7,8] There was no significant difference in vitamin D status with other indicators of socioeconomic status such as level of education, income level, and marital status. This is similar to another study but contrary to the results of another Bangladeshi study which revealed that lower levels of vitamin D were more associated with higher socioeconomic status.[7,8]

There is some evidence that vitamin D is accumulated in adipose tissue with decreased bioavailability and lower serum levels in persons with higher BMI.[28] The lack of any consistent relationship between BMI and vitamin D in our study, similar findings found in another study.[19] The observations of other studies found a significant and negative relationship was found between serum 25(OH)D and BMI.[7,8] As the current study was cross-sectional, it was impossible to determine the causal relationship between obesity as

indicated by BMI and serum 25(OH)D in the study participants. In this study, we did not find any association between the frequency of intake of selected vitamin D-rich foods and vitamin D status. This was similar to the finding of a study among garment factory workers in Bangladesh.[6] It is important to recognize that a diet containing natural vitamin D provides only about 10 percent of the body's vitamin D requirements and is considered a poor predictor of vitamin D status.[3,29] The strength of our study is that we have limitations of this study include relatively small size, failure to study all subjects in both summer and winter. Furthermore, parathormone levels were not available in our study participants.

Conclusion:

Around one-third of the healthy Bangladeshi population had VDD. Besides, around 40% had vitamin D insufficiency. All the potential risk factors, only inadequate skin exposure to sunlight had a significant association with VDD. Increasing outdoor activities along with adequate time and exposure of body surface area to sunlight may prevent VDD in our population.

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