Original Article

Vitamin D Status of Adult Females Residing in Ballabgarh Health and Demographic Surveillance System: A Community-Based Study

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Abstract

Background: Vitamin D deficiency (VDD) is widespread, yet it is the most underdiagnosed and undertreated nutritional deficiency in the world. The prevalence of VDD is estimated to affect over 1 billion people worldwide. **Objectives:** The present study was conducted to estimate the prevalence of VDD among adult females aged 20–60 years residing in a rural community of North India, and to find its association with various sociobehavioral risk factors. **Methods:** The present study is an analytical cross-sectional study conducted among females aged 20–60 years in rural Ballabgarh. Four hundred women were randomly selected from one of the villages of the Health and Demographic Surveillance System. Semi-structured, pretested interview schedule was administered to the study participants. Fasting venous blood sample was collected for the measurement of plasma sugar level and Vitamin D (25-hydroxyvitamin D). **Results:** The prevalence of VDD was 90.8% (95% confidence interval [CI] – 87.5–93.3), while that of Vitamin D insufficiency was 8.9% (95% CI – 6.4–12.2). On logistic regression analysis, 24 h calorie intake, protein intake, and prediabetes status of the participants were significantly associated with VDD. **Conclusion:** Very high prevalence of VDD was observed among the females (20–60 years) residing in rural Ballabgarh.

Key words: Ballabgarh, females, micronutrient, Vitamin D

Introduction

Vitamin D also known as sunshine vitamin is photosynthesized in the skin after exposure to ultraviolet (UV)-B rays. Sun exposure alone ought to suffice for Vitamin D sufficiency. The ubiquitous distribution of Vitamin D receptors in the body, controlled by nearly 3000 genes,[1] suggests that a deficiency could have widespread health implications. Recent studies have examined the physiological functions of Vitamin D beyond its well-established role in musculoskeletal health.[2] It is required in our body to maintain normal blood levels of calcium and phosphorus. Biochemical studies have implicated Vitamin D deficiency (VDD) in many chronic diseases including, but not limited to, infectious diseases, autoimmune diseases, cardiovascular diseases, diabetes, and cancer. Numerous epidemiological publications support the extraskeletal benefits of Vitamin D.[3-5]

VDD is widespread, yet it is the most underdiagnosed and undertreated nutritional deficiency in the world.[6-8] The prevalence of VDD is estimated to affect over 1 billion people worldwide.[9] Although India is a tropical country with abundant sunshine, severe VDD is documented in all age groups (especially postmenopausal women) in several studies from different parts of India.

Countrywide studies have reported that VDD is as high as 70%–100% among healthy individuals.[10] High prevalence of VDD was reported from northern, southern, western, and eastern regions of India, in ostensibly healthy children, adolescents, young adults, and those ≥50 years old. All over India, VDD was highly prevalent in pregnant women and lactating mothers. A study in North India showed high prevalence (84%) of VDD among rural and urban pregnant women, and maternal 25-hydroxyvitamin D [25(OH)D] correlated positively with cord blood 25(OH) D.[11] Participants from rural and urban areas presented a similar

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picture. The prevalence among postmenopausal women was found to be 70% in a South Indian study.[12]

The present study was conducted to estimate the prevalence of VDD among adult females aged 20–60 years residing in a rural community of North India, and to find its association with various sociobehavioral risk factors.

Materials and Methods

The present study is an analytical cross-sectional study conducted in a rural community of Ballabgarh development block in Faridabad district, Haryana. The study area was a Health and Demographic Surveillance System (HDSS) under All India Institute of Medical Sciences, New Delhi, India. The data collection for the study started in November 2013 and was completed in March 2014. The study participants were the women aged 20–60 years and were residing in the area for more than 6 months. The exclusion criteria for the study participants were: (1) received Vitamin D or calcium supplementation in the previous 6 months, (2) on any medication within last 1 month which could potentially influence insulin secretion, insulin sensitivity, Vitamin D or calcium metabolism (e.g., metformin, thiazolidinediones, and steroids) and on any medication that activate steroid and xenobiotic receptors and drugs used in transplantation, (3) pregnancy and lactation at the time of study, (4) severe end organ damage or chronic diseases: renal/hepatic failure, any malignancy, major systemic illness, etc., (5) known case of HIV infection, and (6) known case of diabetes mellitus and other endocrine disorders.

Ethical issues

Ethical clearance was obtained from the Ethics Committee of the All India Institute of Medical Sciences, New Delhi, India. Written consent was obtained from the study participants. Participants with prediabetes, diabetes, and VDD were referred to the Primary Health Centre in the village, which was the nearest government health facility.

With an absolute precision of 5% around and prevalence estimate of 70%,[13] the required sample size was 323 females. To allow for an expected 20% nonresponse rate, a total of 400 females aged 20–60 years were required for the study.

Village Chhainsa was selected for the present study as it was farthest from the urban community (leakage of urban communitization was minimized), had the highest population (among the villages under the Ballabgarh HDSS), and the sociodemographic and other cultural patterns of this village were considered to be almost similar to other rural communities of Northern India. Four hundred women were randomly selected from the list of women of age 20–60 years from Health and Management Information System, a database of the HDSS maintained at Comprehensive Rural Health Services Project Ballabgarh.[14]

Selected women were visited at their house to assess the eligibility. Once the participant was found to be eligible for the study, a written consent was obtained. Interview schedule (semi-structured and pretested) was administered to the enrolled participants. The interview schedule consisted of – sociodemographic factors, behavioral pattern (sun exposure, tobacco use, alcohol use, personal and family history for chronic diseases), anthropometric measurements, vital signs, biochemical test results, food intake, and physical activity. Physical activity status of the study participants was assessed by a validated Global Physical Activity Questionnaire tool.[15] Assessment of food consumption was done by 24 h dietary recall method.

After the administration of interview schedule, 5 ml of venous blood (fasting) was obtained from the participants for estimation of plasma glucose level and 25(OH)D levels. For the present study, fasting was defined as nil orally for a minimum of past 8 h. Blood sample was transported to the laboratory in an appropriate environment for biochemical analysis.

Laboratory investigation

The cutoffs for fasting plasma glucose considered in the present study: normal was 60–100 mg/dl; prediabetes was 100–126 mg/dl, and diabetes was >126 mg/dl.[16]

VDD was defined as plasma level of 25(OH)D <49.9 nmol/L, insufficiency as level between 49.9 and 79.8 nmol/L, and level of more than 79.8 nmol/L was considered to be normal.[17] Serum 25(OH)D levels were measured by chemiluminescence method by DiaSorin LIAISON® 25(OH)D. The LIAISON 25 OH Vitamin D assay was direct competitive chemiluminescence immunoassay for quantitative determination of total 25(OH)D in serum.[18]

Quality assurances

The data collectors were trained and standardized for consistent data collection. Five percentage of the filled forms were randomly selected and refilled and cross-checked by the investigator. Double data entry method was used for data entry. Regarding laboratory investigation, a known control sample was used with every lot of procedure for accuracy and one sample was retested from every lot for reliability of the test.

Statistical analysis

To assess the determinants of the VDD (plasma level of 25(OH)D <49.9 nmol/L), a bivariate analysis with the following dependent variables - age, marital status, educational status, occupation, smoking, sun exposure duration, calorie intake, and protein intake, body mass index (BMI), hypertension, diabetes, and presence of any other chronic illness was performed. $P < 0.05$ was considered to be statistically significant. Bivariate analysis was followed by binary logistic regression with the factors with $P < 0.5$. To assess the sensitivity of the model for determinants of the vitamin deficiency, through logistic regression analysis, receiver operating characteristic (ROC) curve was made. StataCorp LP was used to perform all statistical analysis.

Results

Of the 400 eligible for the study, 392 gave written consent to participate in the study. Blood sample could be collected from 381 participants. The mean age of the study population was 37.7 years with a standard deviation (SD) of 11.7.

The prevalence of VDD was 90.8% (95% confidence interval [CI] – 87.5–93.3), while that of Vitamin D insufficiency was 8.9% (95% CI – 6.4–12.2). Only one participant was found to have Vitamin D level in normal range. Table 1 shows the sociobehavioral characteristics of participants with VDD and nondeficiency. During bivariate analysis, diabetes status and protein intake were found to be associated with VDD in statistically significant manner.

A total of 381 samples were analyzed for Vitamin D; out of which, four samples could not be analyzed for oral glucose tolerance test (OGTT) due to logistic reasons. Moreover, 377 blood samples were analyzed for OGTT to find prediabetes and diabetes (346 of these were Vitamin D deficient and 35 were Vitamin D nondeficient making it a total of 381). There are missing data in blood pressure and BMI so we could give data of 366 in BMI and hypertension status. We could collect proper caloric data for 363. In case of BMI, it is 366 (332 in Vitamin D deficient and 34 were Vitamin D nondeficient), while in hypertension status, it is 366 (334 Vitamin D deficient and 32 were Vitamin D nondeficient).

The mean duration of sun exposure was 159 min (SD: 118) in Vitamin D deficient group in comparison to 175 min (SD: 117) in nondeficient group. The mean calorie intake among the Vitamin D deficient group was 1869 (SD: 510) Kcal while it was 1999 (SD: 519) in nondeficient group. Among the study participants, only 11 (2.8%) reported that they eat egg (once in a week) while only 7 (1.8%) reported that they consumed nonvegetarian food (once in a week).

Table 1: Sociobehavioral characteristics of Vitamin D deficiency

	Vitamin D deficiency		Vitamin D nondeficient		Total		*P*
	n	Mean (SD)/%	*n*	Mean (SD)/%	*n*	Mean (SD)/%	
Age	346	37.5 (11.8)	35	38.3 (11.0)	381	37.7 (11.7)	0.67
Marital status							
Married	281	82.2%	30	85.7%	311	82.5%	0.66
Divorced/separated	25	7.3%	3	8.6%	28	7.4%	
Unmarried	36	10.5%	2	5.7%	38	10.1%	
Total	342	100%	35	100%	377	100%	
Education category							
Illiterate	159	46.5%	19	54.2%	178	47.2%	0.19
Primary	45	13.1%	7	20.0%	52	13.8%	
Secondary	138	40.4%	9	25.7%	147	39.0%	
Total	342	100%	35	100%	377	100%	
Occupational							
Student	16	4.7%	1	2.9%	17	4.5%	0.37
House work	280	81.9%	28	80.0%	308	81.7%	
Service/business	22	6.4%	1	2.9%	23	6.1%	
Labor	24	7.0%	5	14.3%	29	7.7%	
Total	342	100%	35	100%	377	100%	
Tobacco consumption							
Never	316	92.4%	30	85.7%	346	91.8%	0.19
Sometimes	26	7.6%	5	14.3%	31	8.2%	
Total	342	100%	35	100%	377	100%	
Sun exposure duration	342	159.0 (118.0)	35	175.4 (117.3)	377	162.0 (118.7)	0.43
Calorie intake*	329	1868.8 (510.2)	34	1998.5 (519.2)	363	1880 (508.9)	0.17
Protein intake*	329	51.34 (15.3)	34	48.7 (13.9)	363	51.1 (15.1)	0.32
BMI*	332	22.8 (4.6)	34	23.2 (4.0)	366	22.8 (4.6)	0.58
Hypertension status*							
Normal	203	60.8%	18	56.3%	221	58.6%	0.61
Prehypertensive and hypertensive	131	39.2%	14	43.8%	145	38.5%	
Total	334	100%	32	100%	366	97.1%	
Diabetes status							
Normal	332	97.1%	31	88.6%	363	96.3%	0.03
Prediabetes and diabetes	10	2.9%	4	11.4%	14	3.7%	
Total	342	100%	35	100%	377	100%	
Presence of any chronic illness							
Absent	295	86.3%	31	88.6%	326	86.5%	0.7
Present	47	13.7%	4	11.4%	51	13.5%	
Total	342	100%	35	100%	377	100%	

*Few participants did not respond to the question. SD: Standard deviation, BMI: Body mass index

None of the study participants reported consuming alcohol, while 7.6% of Vitamin D deficient were consuming any kind of tobacco products in comparison to 14.3% of nondeficient group consuming tobacco. During bivariate analysis, only prediabetes/diabetes condition of the participant had statistically significant association with the VDD [Table 1].

In binary logistic regression analysis, educational status, occupation, smoking, sun exposure duration, calorie intake, and protein intake were used in the model since during bivariate analysis, these variables had $P < 0.5$ [Table 2].

During the multivariate analysis, nutrient factors (calorie and protein intake) were found to be statistically significant. While women with diabetes/prediabetes had 5-fold increased risk of VDD, this association was statistically significant as well. The area under the ROC curve was 0.6886 [Figure 1]. The *P* value for the Hosmer–Lemeshow goodness of fit for models was 0.24.

Table 2: Multivariate analysis to find association between Vitamin D deficiency with sociobehavioral risk factor

	Adjusted OR	95% CI		*P*
		UCI	LCI	
Education category				
Illiterate	1 (reference group)			
Primary	1.8	0.65	5.1	0.244
Secondary	0.5	0.20	1.5	0.228
Occupational category				
Student	1 (reference group)			
House work	1.1	0.12	9.3	0.960
Service/business	0.7	0.04	13.4	0.820
Labor	1.6	0.13	19.7	0.720
Smoking	1.5	0.42	4.9	0.553
Sun exposure duration	1.0	1.00	1.08	0.770
Caloric intake	1.1	1.001	1.10	0.001
Protein intake	0.9	0.90	0.98	0.001
Prediabetes and diabetes	4.9	1.341	18.27	0.016

OR: Odds ratio, CI: Confidence interval, UCI: Upper CI, LCI: Lower CI

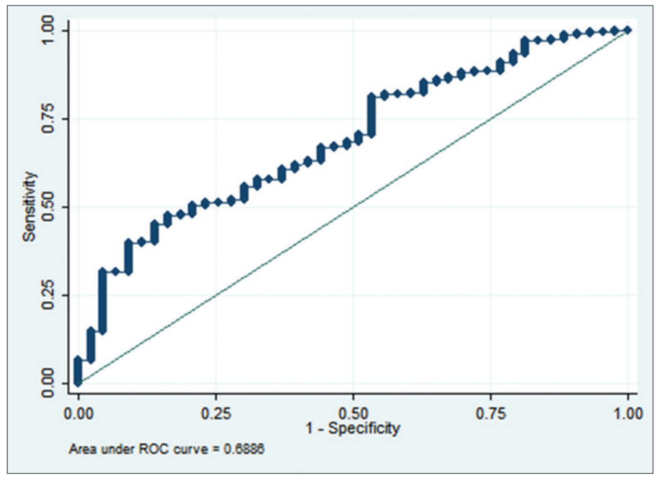

Figure 1: Receiver operating characteristic curve for predictive value of the model for Vitamin D deficiency.

Discussion

Prevalence of VDD was as high as 91% in our study. All participants except one had low Vitamin D levels, i.e. almost all the study participants had either VDD or insufficiency. Very high prevalence of VDD has also been reported from various other studies in the northern part of India. In North India, 96% of neonates, 91% of healthy neonates, 78% of healthy hospital staff, and 84% of pregnant women were found to have VDD.[11,19-22] Further, a review by G Ritu *et al*.[10] reported that the VDD was as high as 70%-100% among healthy individuals. In fact, 14%–32% of females (20–30 years of age) from the Indian paramilitary forces were found to be osteopenic at different bone sites. These individuals consumed a nutritious, high-protein diet, had optimal exposure to sunlight, and undertook strenuous outdoor physical exercise.[23]

Probable reasons for high prevalence of VDD could be inadequate exposure to sunlight or inadequate intake of calcium. In the present study, the study area – Ballabgarh HDSS was located between 28° 25' 16" North latitude and 77° 18' 28" East longitude. The average duration of cloud-free sunshine was 8–10 h/day during the period of data collection (November–March). The UV index at this latitude during the study period was 7–10.[24] Lo *et al.* report that Asian Indians require twice as much UV-B exposure to produce 25(OH)D levels as compared to Caucasians due to increased skin pigmentation.[25] Thus, for Indian skin tone, minimum "direct sun exposure" required daily is more than 45 min to bare face, arms, and legs to sun's UV rays (wavelength 290–310 nm). With the exception of those who perforce need to work outdoors in the sun, most Indians do not get adequate sun exposure to produce sufficient amounts of Vitamin D endogenously.[26]

In the present study, the mean duration of sun exposure was fairly high. Based on the available literatures, it was noted that during that season, most of the body parts are covered and also the UV index is low during that period.[26]

Most dietary sources of Vitamin D have very low Vitamin D content. Most of the food items rich in Vitamin D are of animal origin while most Indians are vegetarians. In the present study as well, rarely, the study participants were consuming food of animal origin on a regular basis. The most common food of animal origin in study area consumed was milk and the Vitamin D content of unfortified milk is very low (2 IU/100 mL); so, Vitamin D consumption is very low in the study area. Low dietary intake of calcium in conjunction with Vitamin D insufficiency is associated with secondary hyperparathyroidism which is further associated with increased morbidity associated with VDD. This mechanism also explains the low 25(OH)D levels in rural participants on a high phytate and/or low calcium diet despite plentiful sun exposure.[27] Furthermore, the high salt content of Indian diet is likely to increase urinary calcium excretion. A direct relation between high sodium intake and lower bone mass has been reported.[28]

In the present study, the association between the presence of any of the chronic disease (hypertension, obesity, COPD, cardiovascular diseases, malignancy, skeletal and bone disorders) was found to be statistically nonsignificant. However, association between individual chronic disease and VDD could not be studied in the present study as the sample size for this was not sufficient. There are several studies to show association between VDD with oncologic, immunologic, and cardiometabolic risk factors including type 2 diabetes, blood pressure, and obesity.[29-33]

Limitation of the study

There is no universal definition for cutoff value of VDD, and it seems that it varies in different populations. The Vitamin D cutoffs used in the present study were derived from the study participants in the Western world. High prevalence of VDD may be because of the cutoff values which is not appropriate for the present study participants.

Conclusion

Very high prevalence of VDD was observed in the females (20–60 years) of Ballabgarh HDSS. Further to it, this study has found that females though residing in rural area where sun exposure is good, still have VDD. These females are well exposed to sun on most of the days not only in leisure time but also during household work. So, is it really a VDD or we need different cutoff for Indian Population? Studies are needed to further explore the reasons for same.

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Conflicts of interest

There are no conflicts of interest.

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