Dr P C Sen Best Paper Award on Rural Health Practice

Original Article

Sun Exposure and Vitamin D in Rural India: A Cross-Sectional Study

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Abstract

Background: Vitamin D deficiency/Vitamin D Insufficiency (VDI) is now recognized as a pandemic. Cutaneous exposure to ultraviolet-B causes photolysis of epidermal 7-dehydrocholesterol, converting it to pre-Vitamin D3 (precholecalciferol), which then undergoes isomerization to form the stable hormone Vitamin D3. **Objectives:** The objectives of the study is to determine the status of Vitamin D level among the adults residing in a rural area of West Bengal and to find out the optimal cutoff of the sun exposure for Vitamin D sufficiency. **Methods:** This study was a rural community based cross-sectional study. It was done from May 2016 to April 2017 among 197 adults residing in a rural block of West Bengal. Data were collected by interviewing the respondents with the help of a structured pre-tested pre-designed schedule. After interviewing, every individual was examined for height and weight and blood was collected for serum Vitamin 25-(OH) D. Receiver Operating Characteristic (ROC) curves were utilized to find out optimum cut-off for sun exposure using Youden's index. Binary logistic regression was performed to find out the associates of high sun exposure. All analysis was done using R. **Results:** Overall VDI was found in 133 (67.5%). Among them, 102 (51.8%) were female. On ROC curve for veritable sun exposure for Vitamin D sufficiency, area under curve was 0.7841 which signifies veritable sun exposure as a good screening tool. **Conclusion:** Proper information, education, and communication material regarding various aspects of sun exposure and Vitamin D should be prepared with due consultation of field experts and disseminated to increase awareness among the community.

Key words: Receiver operating characteristic curves, sun exposure, Vitamin 25-(OH)D

Introduction

Vitamin D has been traditionally known as antiricketic factor or sunshine vitamin. Vitamin D is not really a vitamin at all. It is a steroid which, in its active form, has a hormone activity. By definition, Vitamin D is a hormone because it is made in one organ (skin) and transported by body fluid (blood) to act or activate other body parts.[1,2]

Vitamin D deficiency/insufficiency (VDD/VDI) is now recognized as a pandemic. VDD is a major public health problem worldwide in all age groups, even in equatorial regions where ultraviolet (UV) rays were assumed to be adequate enough to prevent this deficiency. Across the globe, over a billion people have low Vitamin D levels irrespective of age and ethnicity.[3-7] It has been a general belief that VDD is uncommon problems in India because of abundant sunshine.[8,9] However, this is not true. VDD prevails in epidemic proportions all over the Indian subcontinent, with a prevalence of 70%–100% in the general population.[8,10-12]

Usually, 50%–90% of Vitamin D is produced by sun exposure of skin, and the remainder comes from the diet. Exposure to UV-B causes photolysis of 7-dehydrocholesterol in the skin, converting it to pre-Vitamin D3 (precholecalciferol), which then undergoes isomerization to form the stable hormone Vitamin D3 (Cholecalciferol).[1] Vitamin D3 circulates to the liver and kidney where it is finally converted to the di-hydroxylated functional hormone 1,25-dihydroxyvitamin (Calcitriol).[13]

The ability to form precholecalciferol is affected by various factors such as latitude, season and diurnal variations, zenith

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Access this article online

Quick Response Code:

Website: www.ijph.in

DOI: 10.4103/ijph.IJPH_258_18

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How to cite this article: Garg S, Dasgupta A, Maharana SP, Paul B, Bandyopadhyay L, Bhattacharya A. Sun exposure and Vitamin D in rural India: A cross-sectional study. Indian J Public Health 2018;62:175-81.

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angle, and time of day. Atmospheric pollution weakens solar radiation. Dress code, skin pigmentation, and application of sun protection factor of 15 reduce the UV-B penetration into epidermis by more than 95%, thereby limiting the production of Vitamin D3.[14-28]

As with recent progress in the field of medicine, it is now clear that Vitamin D has its effect on overall health, besides its effect on bone health such as on glycemic control, on immunity, on various malignancies, on lipid profile, on cardiovascular diseases, increasing neuromuscular function and improving mood, protecting the brain against toxic chemicals, and potentially reducing pain, and on various other aspects of health.[29,30]

Overall, Vitamin D is a versatile yet crucial factor which is vital for many metabolic functions in our body. However, it is not given due importance. Vitamin D costs nothing. It is freely available to everyone who allows adequate exposure of skin to the sun-rays. The main reason for VDD is insufficient consumption of Vitamin D in combination to inadequate sun exposure.

Various researches from all over India have shown a high prevalence of VDD both in rural and urban populations.[31] With this background the present study was conducted in a rural block West Bengal, India, to determine the status of Vitamin D level among the adults, to quantify the sun exposure, to find out the optimal cutoff value of the sun exposure for Vitamin D sufficiency and to elicit the determinants of high sun exposure.

Materials and Methods

This study was a rural community-based cross-sectional study. It was done from May 2016 to April 2017 among adults residing in a rural block of West Bengal, India. Pregnant and lactating women, all those who had not given written informed consent, who were critically ill and who had Vitamin D supplementation within the past 6 months were excluded from the study.

As this kind of study, i.e., study on VDD/VDI has not been conducted in this part of the country on a community basis, reference of a study done in Mangalore has been considered for sample size calculation where the level VDI was 80%,[32] after taking a confidence interval of 95%, relative error as 10%, and design effect as 2 minimum sample size was 196.

Rural Health Unit and Training Center, Singur (RHUTC) is the rural field practice area of All India Institute of Hygiene and Public Health (AIIHPH), Kolkata, which serves 64 villages through two of its Union Primary Health Center (UPHC). Each UPHC serves 32 villages. Multistage sampling was used to recruit the study participants. In the first stage, 3 villages were selected randomly from the 32 villages of each UPHC. A line listing of all the adults from selected villages was done and number of participants from each village was calculated by Population Probability to Size Sampling. The required number of samples were drawn from a list of each village by simple random sampling (SRS). If the selected individual was found to be as per exclusion criteria or was unable to contact after two visits, SRS was done again without replacement.

The study was started after the due permission of the Institutional Ethics Committee of AIIHPH. Data were collected by the researcher himself after taking written informed consent by interviewing the respondents with the help of a structured pre-tested pre-designed schedule. At the end of the study, advice was given about preventive measures of VDI and also the treatment for the VDI by the researcher. The Schedule had six parts.

Sociodemographic characteristics, sun exposure, and usual clothings, physical activity; short International Physical Activity Questionnaire (IPAQ), Questionnaire for musculoskeletal morbidity, Awareness regarding Vitamin D, Questions related to depression[33]

a. Sociodemographic characteristics: Age, sex, religion, education, type of family, marital status and socioeconomic status
b. Sun exposure and usual clothings: Each individual was asked about the usual daily sun exposure and the usual body parts exposed to sunlight during the hours of sun exposure. Total body surface area (BSA) exposed to sunlight was calculated using Lund and Browder chart.[34] A new variable named "Veritable Sun Exposure" was computed by multiplying daily sun exposure in hours and BSA (%)
c. Physical activity; short IPAQ: Each individual was asked about their various activities in the last 7 days
d. Questionnaire for musculoskeletal morbidity: Numbers of painful body sites were reported for each individual
e. Awareness regarding Vitamin D: Two questions were asked to assess the awareness regarding Vitamin D
   - Have you ever heard about Vitamin D? Yes/No, if yes
   - Do you know the symptoms of VDI? Yes/No

   One' mark was given to individuals who gave response "Yes" for the first question. Similarly, "One" mark was given to individuals who gave anyone correct response for the last question
f. Questions related to depression: Four questions were asked for four depressive symptoms as per Diagnostic and Statistical Manual of Mental Disorders IV
   - Do you think your life is meaningful?
   - Do you think you make decisions quickly?
   - Are you enjoying your life?
   - Do you feel others rely very much on you?

After interviewing every individual was examined for height and weight and blood was collected for Vitamin 25-(OH)D. Blood was collected from cubital vein and transported to pathological laboratory for serum Vitamin 25-(OH)D levels. Height was measured in standing position against a hard wall with occiput, shoulder blades, buttocks, and heel touching the wall without any footwear and headwear with nonstretchable measuring tap with the precision of 0.1 cm. Weight was measured with properly calibrated digital weighing scale with

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a precision of 0.1 kg with participants standing in straight position with minimum respectable clothings.

Operational definition

- Vitamin D insufficiency: VDI is defined as serum Vitamin D 25-(OH) level <30 ng/ml.[32]
- Good Awareness regarding Vitamin D: Individuals who had scored one or more than one score were classified as having good awareness
- Body mass index (BMI): Each individual was classified into different BMI categories as per South Asian WHO criteria
- High Sun Exposure: A optimum cutoff for veritable sun exposure was found using Receiver Operating Characteristic (ROC) curve for Vitamin D sufficiency. Individuals with veritable sun exposure more than equal to this cutoff were stated as having high sun exposure.

Recorded data were analyzed using appropriate statistical methods and represented by various tables, graphs, diagrams, etc., and various statistically significant tests were applied accordingly with the use of R: A language and environment for statistical computing. ROC curves were utilized to find out optimum cutoff for daily sun exposure and veritable sun exposure using Youden's index. Univariate and forced multivariable binary logistic regression was performed to find out the associates of high sun exposure.

Results

Mean (standard deviation [SD]) Vitamin D Level among study participants was 27.01 (6.8) ng/ml with a median of 26.30 ng/ml. Minimum Vitamin D level was 7.1 ng/ml and maximum was 45.70 ng/ml. Among the study participants, 31 (15.7%) had VDD. Only 64 (32.5%) had Vitamin D more than or equal to 30 ng/ml. Overall VDI was found in 133 (67.5%) of the study participants [Figure 1].

Mean (SD) age of the study participants was 42.8 (15.3) years. Among them, 102 (51.8%) were females. Only 30 (15.2%) were Muslims and 136 (69.0%) were currently married at the time of the survey. Mean (SD) years of completed schooling was 7.58 (4.62) years. Only 51 (25.32%) of the participants had an education level of higher secondary and above (12 standard pass and above). Out of them, 69 (35.0%) were predominantly outdoor workers. Mean (SD) per capita income was 2.14 (1.80) 1000 INR. According to Modified B. G. Prasad, 58 (29.4%) and 7 (3.6%) of the participants were from class V and class I, respectively. Only 63 (32%) had good awareness regarding Vitamin D. Data revealed that 80 (49.6%) were vigorous physical worker and 111 (56.4%) were overweight/preobese/obese.

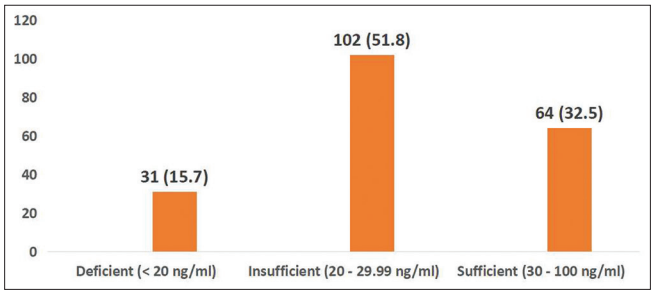

Figure 1: Vitamin D status among study participants (n = 197).

Majority of the participants, 167 (84.8%), 126 (64%), and 124 (62.9%) reported lower, upper back pain, and knees/calves pain, respectively. Of 197 study participants, 43 (21.8%) had "Four" painful sites. Only 12 (6.1%) participants had no pain while 25 (12.7%) had "Seven" or more painful sites.

Out of them, 103 (52.3%) felt that their life was meaningful and 107 (54.3%) reported that they could make decisions quickly. On asking regarding depressive symptoms, 50 (25.4%) participants had no depressive symptom while 34 (17.2%) had "Four" depressive symptom.

On asking about the time, they usually spent under sunlight, 85 (43.14%) replied within 30 min, only 1 stated that they did not spend any time under sunlight. Only nine study participants were reported to have daily sun exposure of more than 3 h [Table 1].

All of them said that they use to uncover their face when they are exposed to sunlight. Most of them, 161 (81.7%) had their neck exposed and 137 (69.5%) had their hands exposed when they were under sunlight. Only 47 (31%) and 45 (22.8%) stated that their legs and feet respectively exposed to sunlight. Out of 197 study participants, 12 (6.1%) had <10% BSA exposed to sunlight while 87 (44.2%) had more than 20% BSA exposed to sunlight.

Mean veritable sun exposure was 32.67 (37.82) % hour per day. Out of 197, 68 (34.9%) had 0%–10% h/day veritable sun exposure [Table 1].

On ROC curve for veritable sun exposure for Vitamin D sufficiency, area under curve (AUC) was 0.7841 which signifies veritable sun exposure as a good screening tool. With Youden's method as well with closest to top-left method, optimum cutoff of veritable sun exposure was found to be 17.375% area hour/day. At this cutoff, an individual had

Table 1: Sun exposure among study participants (n=197)

	n (%)
Sun exposure per day (h)	
0.00-0.50 (30 min)	85 (43.14)
0.50-1.00	30 (15.23)
1.00-2.00	37 (18.78)
2.00-3.00	36 (18.27)
>3.00	9 (4.58)
Veritable sun exposure (percentage hour per day)	
0-10	68 (34.9)
10-20	41 (20.8)
20-30	9 (4.5)
30-40	18 (9)
40-50	17 (8.6)
≥80	44 (22.3)

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minimum Vitamin D level of 30 ng/ml with a sensitivity of 79.68% and specificity of 71.43%. On ROC curve for daily sun exposure (hour per day) for Vitamin D sufficiency, AUC was 0.7846 which signifies daily sun exposure as a good screening tool. With Youden's method as well with Closest to top-left method, optimum cutoff of daily sun exposure was found to be 1.75 h/day. At this cutoff, an individual had minimum Vitamin D level of 30 ng/ml with a sensitivity of 75% and specificity of 77.44% [Figure 2].

After dichotomizing veritable sun exposure according to cutoff found at ROC, i.e., 17.375% h/day for Vitamin D sufficiency, 108 (54.8%) of the study participants had low veritable sun exposure. On univariate binary logistic regression for high sun exposure, males (odds ratio [OR] = 3.28), outdoor workers (OR = 6.71), and individuals with vigorous physical activity (OR = 19.3) were found to have significantly higher veritable Sun exposure. Decreasing numbers of painful musculoskeletal sites (OR = 1.64) and decreasing numbers of depressive symptoms (OR = 1.49) were found to be significantly associated with higher odds of veritable sun exposure. After adjusting all the significant variables in univariate regression, outdoor worker (adjusted OR [AOR] = 3.13), individuals with vigorous physical activity (AOR = 11.8) and individuals with less numbers of musculoskeletal painful sites (AOR = 1.69) were found to have significantly higher veritable sun exposure. Regression model can predict veritable Sun exposure accurately by 81.2% Independent variables in a regression model can predict 59% variance in veritable sun exposure according to Nagelkarke R^2. The model was fit as shown by Hosmer-Lemeshow statistics [Table 2].

Discussion

Various studies across the entire country on various study population such as pregnant women, PMW, elderly, paramilitary professionals, nurses, doctors, hospital staff, and adults have reported VDD (ranging from 41% to 100%), VDI (ranging from 73% to 100%), and mean Vitamin D level (ranging from 10 to 28.86 ng/ml).[35-45]

Table 2: Factors associated with High Sun Exposure: Univariate and Multivariable Logistic Regression (*n*=197)

Variables	High sun exposure, *n* (%) (*n*=89)	OR (95% CI)	AOR (95% CI)
Age (↓)		1.01 (0.97-1.009)	NA
Gender			
Male (*n*=97)	57 (60.0)	3.28 (1.84-5.95)	1.18 (0.41-3.25)
Religion			
Hindu (*n*=167)	79 (47.3)	1.79 (0.81-4.16)	NA
Education (↑)		1.02 (0.96-1.09)	NA
PCI (↓)		1.02 (0.87-1.19)	NA
Occupation			
Outdoor worker (*n*=69)	51 (73.9)	6.71 (3.53-13.22)	3.13 (1.11-6.71)
Physical activity vigorous (≥3000 met-min/week) (*n*=80)	66 (82.5)	19.3 (9.5-31.5)	11.81 (5.38-15.53)
BMI			
<23.00 kg/m² (*n*=86)	44 (51.2)	1.54 (0.87-2.72)	NA
Awareness regarding Vitamin D			
Good (*n*=63)	27 (42.3)	1.27 (0.70-2.32)	NA
Number of painful sites (↓)		1.64 (1.39-1.97)	0.94 (0.67-1.30)
Number of depressive symptoms (↓)		1.49 (1.21-1.84)	1.69 (1.33-2.21)
Hosmer-Lameshow statistics			0.3384
McFadden's pseudo-R^2			0.42
Nagelkarke pseudo-R^2			0.59
Cox and Snell pseudo-R^2			0.44
Accuracy by confusion matrix			81.2%

↑Increasing, ↓Decreasing. AOR: Adjusted odds ratio, NA: Not applicable, OR: Odds ratio, CI: Confidence interval, BMI: Body mass index

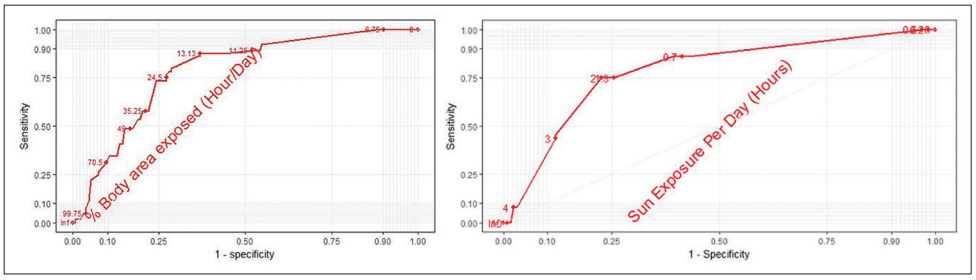

Figure 2: Receiver operating curve for veritable sun exposure and daily sun exposure for predicting Vitamin D sufficiency (Vitamin D ≥30 ng/ml) (*n* = 197).

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Almost all previous research works in our country have found higher VDI/VDD than our finding, and this may be due to various reasons, such as:

- The rural setting of our study while most of the other studies have been conducted in urban settings
- Cultural differences between the study populations such as staple food, living style, and physical activity
- In West Bengal, staple food is fish and eggs, which are among the few food items in which Vitamin D is available. This food habit may be the reason of less prevalence of VDD/VDI in our research
- As we have done our study in a village, number of participants with physical inactivity and with obesity were very low. This may also explain the less prevalence of VDD/VDI in our research.

About 40% of the study participants in the study had sun exposure of more than 60 min which is similar to the study done in rural Mahad, Maharashtra.[35] The similarity in the research might be due to the rural setting of both studies. Mean sun exposure of the participants in the present study was 90 min which is higher than that of other studies where study participants were physicians, pregnant women, and depigmented persons in Delhi by Goswami *et al*.[46] However, in the latter study, soldiers were found to have quite more sun exposure than our study participants. All these variations may be attributed to urban setting of latter study and different occupation and physiological status of study participants. A study among healthy individuals in Kashmir valley mean sun exposure was 142 min/day.[47] This is higher than that of our study participants, and it may be due to all the study participants in the latter study were adults while the present study had 25% elderly population.

Two studies among pregnant women in Lucknow[48] and Mumbai[45] had found mean BSA % hour exposed to sun 6% and 7% h/day, respectively. This might be due to physiological status of study participants and urban setting in the latter studies. A study among pregnant women[49] found 35.4% h/day in rural Lucknow which is similar to our finding, and it might be attributed to rural setting of both studies.

As per the researcher's knowledge, no such attempt was made to find out optimum cutoff for a combined characteristic which considers not only sun exposure but also area exposed to sunlight and daily sun exposure. Findings of the present study suggest that if around 17%–18% BSA human body will expose to sunlight for 1 h in a day, then the individual will have Vitamin D sufficiency. The possible favorable combination in our Indian culture may be exposed face, hand including palm, neck, and feet for "1" h.

Males had higher odds for sun exposure, and this may be very easily explained by the cultural setting of rural India, where women usually are homemakers and hence for most of their time, they spend inside the house and hence low sun exposure. Outdoor workers had more sun exposure than indoor workers, and again this finding is too obvious as mostly an individual works during daytime; hence, it is not surprising to have low sun exposure for an indoor worker. The present study found higher the physical activity, higher the sun exposure. As most of the activity, which constitute physical activity are usually outdoor such as cycling, swimming, running, and others and hence more sun exposure. Individuals with more depressive symptoms were found to have low sun exposure. This may be due to the fact that depressive individuals want to be alone and in trying to be alone, they usually prefer to stay inside their house and hence low sun exposure. Individuals with higher sites with pain were found to have lower sun exposure than the individuals with fewer sites of pain. This association can be explained in two ways, first that individuals with low sun exposure will have low Vitamin D, therefore more pain and second that individuals with pain will rest inside, hence will have low sun exposure.

Strength and limitations

The present study was a community-based study on VDD/VDI. There is no such study in this part of the country as per researcher's knowledge. Findings of the present research can be generalized to other similar settings as the sample size was calculated scientifically. It is the first to find out the optimum cutoff level of sun exposure for optimal Vitamin D level.

The study was cross-sectional in nature, and hence temporal association could not be established. Some of the responses were self-reported and recall based. Hence, responses might be biased due to recall or due to social desirability bias.

Conclusion

Proportions of VDI varied from 57% to 100% depending on gender and age. Overall, the prevalence of VDI was 67.5%. Awareness or proper knowledge is prerequisite for favorable practice. Proper information, education, and communication materials regarding various aspects of sun exposure and Vitamin D should be prepared with due consultation of field experts and disseminated to increase awareness among the community. Exposure of face (3.5%), forearm (6%), hand (6%), and neck (2%) for "1" h may give sufficient Vitamin D levels. Participants of all age groups, in both genders, in urban and rural areas and different parts of the country with a larger sample should be studied in the future.

Acknowledgments

We would like to thank the officer in-charge and staff of RHUTC, Singur for their help and cooperation in conducting the study. We would also like to thank the health workers for helping us during our field visits. We sincerely thanks to all the developers of R software.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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PROFORMA OF NOMINATION FOR THE ELECTION OF OFFICE BEARERS, C.C. MEMBERS AND EDITORIAL BOARD

We hereby nominate Sri / Smt./ Dr./ Prof. .....

Designation: .....

Address: .....

IPHA Membership No. ..... **Mobile:**.....

Email ID of Candidate: ..... **Fax:** .....

For the post of ..... **for the Term** .....

For the region (if applicable)....., **Date:** ..... **Place:** .....

Proposed by:

Name in block letter.....

IPHA Membership No. :.....

Signature.....

Seconded by:

Name in block letter.....

IPHA Membership No. :.....

Signature.....

Date: .....**Place**.....

Date:.....**Place**.....

I hereby give my consent for the above mentioned post. My bio-data and a draft of Rs. 500/- in favour of " Indian Public Health Association" Payable at Kolkata (Draft No. .....

Date.....**Bank**.....**) are enclosed herewith. I also certify that I have not** been elected and served **for two consecutive terms in the same post.**

Full signature of the candidate .....

Date: ..... **Place:**.....

N.B. Enclose Bio-data containing Name, Date of Birth, Qualification, Present position, professional Experience in years, Total year of Membership, Duration of Membership of IPHA and other organizations, Whether holding any post of office bearers / Central Council member in the Headquarter Secretariat or in its branches as office bearers or Executive Body members, Achievements awards, fellowships and projects, publications and other relevant information, if any.

As per decision of the Annual General Body meeting held at Nagpur in the year 2003, a non-refundable fee of Rs. 500/- as a demand draft in favour of "Indian Public Health Association" should be enclosed along with each nomination form, otherwise nomination will be considered invalid.