Impact of Seasonal Variation in Association with Other Factors on Vitamin D Status among Mangalorean Population

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ABSTRACT

BACKGROUND
India has plenty of sunshine, yet people here are deprived of vitamin D – 'sunshine vitamin'. According to endocrine society of India, vitamin D levels of < 20 ng / mL is considered to be vitamin D deficiency. The objective of the study was to evaluate seasonal variation of vitamin D and give an insight on risk factors such as age, gender, diet, body mass index, occupation, skin complexion and body surface area exposure on vitamin D level.

METHODS
The study was conducted in a tertiary hospital in Mangalore on 109 apparently healthy individuals. The same cohort of subjects was followed for two seasons - summer and winter. Serum was collected and analysed for 25-OH vitamin D, calcium and phosphorous. Skin color was assessed according to the Fitzpatrick classification, questionnaire was given to assess the approximate time limit of sun exposure in a day along with the exposed areas to sunlight and anthropometric parameters such as height and weight were measured using standard guidelines. Body mass index (BMI) was calculated. Comparison of mean vitamin D along with the factors influencing them in both seasons was done using paired t test. Inferential statistical analysis was done using chi-square test. Pearson correlation test was also done. Statistical significance was considered at $P < 0.05$.

RESULTS
Mean vitamin D was higher in summer (15.14 ± 5.62) as compared to winter (14.42 ± 5.38) irrespective of the risk factors. Vitamin D deficiency was highest in older age group (83.9 %), females (84.6 %), overweight (100 %), vegetarians (92.3 %), office workers (91.2 %), both complexions and those exposed with < 1.5 hours of sunlight (97.2 %). Vitamin D deficiency was also more prevalent in those with lesser exposed body surface area.

CONCLUSIONS
Vitamin D deficiency was statistically most common in winter than summer. It was seen correlating with majority of the risk factors, except skin complexion and among the confounding factors. The key for vitamin D production in this population was maximum body surface area exposure (face, hand, leg and feet) to sunlight for more than 2.5 hours, yet these subjects were vitamin D deficient. However, they did not manifest with any skeletal or extra-skeletal morbidity. Thus, concluding that a reliable cut off value for reference range of vitamin D should be set in this population in order to abstain from excess vitamin D treatment.

KEY WORDS
Sunshine Vitamin, Vitamin D Deficiency, Mangalore, Skin Colour, Sunlight Exposure, Body Surface Area, Summer, Winter

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BACKGROUND

India has plenty of sunshine, yet people here are deprived of vitamin D – 'sunshine vitamin', with a prevalence of 70 – 100 %.[1] The primary source of this vitamin is endogenously produced in the skin by its exposure to solar ultraviolet B (UVB) rays. It causes the conversion of 7-dehydrocholestrol to calcitriol which is the functional form of vitamin D via two steps. The dietary sources for vitamin D are mainly non-vegetarian food and fortified vitamin D supplements but the amount of vitamin D present in these is insufficient.[2]

Latitude of residence and geographic locations play a vital role in the synthesis of this vitamin. The maximum amount of UVB rays are received by places near the equator and India is located north of the equator at 8.4 and 37.6 N latitude making it abundant with UVB rays. Accordingly, time of the day, seasons and atmospheric pollution influence the synthesis. Considering cutaneous source as the primary source of vitamin D, there are complex variables altering the production such as duration of sun exposure, area exposed and skin pigmentation.[3] Exposure of 100 % body surface area to sunlight giving a slight pink discoloration of skin minimal erythemal dose (I MED) is equivalent to ingesting around 20,000 IU of vitamin D orally.

Therefore, exposure of 6 % of the body to sunlight (1 MED) is equivalent to ingesting about 600 – 1000 IU of vitamin D. The time exposure for Asians with skin type V at 11.5^0 N is 10 - 15 minutes and 10 - 45 minutes at 29^0 N noon and a longer duration during winter. The duration of sun exposure is even less in Caucasians with type II or III skin type as increase in melanin reduces the absorption of UVB radiation that enters the skin.[4] Demographic features too impose a risk factor on vitamin D production; it has been proposed that obesity reduces the bioavailability of vitamin D, due to its increased uptake by fatty tissues.[5]

Vitamin D levels of < 20 ng / mL is considered to be vitamin D deficiency according to endocrine society of India.[6] Vitamin D deficiency causes multi factorial implications on skeletal as well as extra skeletal systems, which has become a cause of concern among health care organisations. The Institute of Medicine (IOM) emphasised that serum 25 (OH) D level more than 30 ng / mL had no extra benefits on parathyroid hormone suppression, calcium homeostasis and skeletal effects, therefore > 20 and is considered vitamin D sufficient.[7,8]

Sunlight playing the major role in the production of vitamin D, ample amount is got in Mangalore on an average over 8 hours / day in summer and 7 hours a day in winter with maximum UVB rays being received in this region (latitude 12.91 N and longitude 74.85 E). Astonishingly even then the population here are suffering from hypovitaminosis D and are getting treated for the same.

Therefore, a study to evaluate the discrepancy between the vitamin D levels in winter and summer seasons is mandatory. This study was conducted to give an insight on the role of other associated risk factors such age, gender, body mass index (BMI) and diet on the vitamin D status. It also implies on knowing the association of vitamin D to the hours of sun exposure along with the exposed body surface area and the skin color. The present study was conducted to explore the prevalence of vitamin D deficiency among the risk factors in this population.

METHODS

A cross sectional study was conducted on 109 apparently healthy individuals who visited A.J. Institute of Medical Sciences & Research Centre, Mangalore and were residing in this city for more than 5 years. The duration of the study was from January 2018 to January 2019. The same cohort of subjects were followed over two seasons, summer and winter. However, a similar study with such extensive assessment of risk factors associated with vitamin D deficiency and impact of seasonal variations on this parameter was not done in this part of the population. The subjects who were excluded were the ones with chronic illness, liver disorder, renal dysfunction, malabsorption syndromes, subjects on vitamin D supplements, calcium supplements, diabetics, hypertensives, autoimmune disorders, sunscreen users, pregnant ladies and those ladies who have to cover themselves in order to follow their religious believes.

After obtaining ethical clearance from the institutional ethical committee, an informed consent was obtained from the selected subjects and 5 mL of blood sample was collected in a plain vacutainer twice from each subject according to the seasons mainly summer (months included are March, April and May) and winter (months included are November, December and January) which was centrifuged for 10 minutes at 4000 rpm. The serum, thus obtained, was analysed for serum calcium by Arsenazo method, phosphorous by phosphomolybdate method and 25 hydroxy (25-OH) vitamin D by chemiluminescence immunoassay ARCHITECT ci 4100 (Abbott Diagnostics).

Skin colour was assessed according to the Fitzpatrick classification. It is classified into six skin types based on the skin reaction to sun exposure and the skin colour. The subjects were asked regarding the change in the skin on exposure to sun for about 30 to 60 minutes and accordingly they were dichotomised into the six photo types. In addition, the subjects were asked to fill a questionnaire regarding the approximate time limit of exposure to sunlight in a day along with the exposed areas to sunlight and anthropometric parameters such as height and weight were measured using standard guidelines. Body mass index (BMI) was calculated.

Data analysis was done using Statistical Package for the Social Sciences (SPSS) version 20. Categorical variables were represented as frequency and percentage and quantitative variables were represented as mean and standard deviation. Comparison of means between two groups was done using independent t test while analysis of variance (ANOVA) test using Tukey's test for post hoc analysis was done for comparison of means between more than two groups. Comparison of mean 25-OH vitamin D levels in summer and winter seasons was done using paired t test. Chi-square test was used to test the association between categorical variables. Pearson correlation test was done to correlate the various variables. Statistical significance was considered at $P < 0.05$.

RESULTS

The study comprised of 109 subjects, with mean vitamin D level higher in summer season than in winter (15.14 ± 5.62 & 14.42 ± 5.38). The increase in mean vitamin D levels was statistically significant (P < 0.001). There was no significant difference in mean calcium (9.02 ± 0.27) (9.01 ± 0.26) and phosphorus (3.88 ± 0.26) (3.88 ± 0.27) levels between the two seasons. (Table 1).

Across age groups, the mean vitamin D levels decreased as the age progressed < 30 years the vitamin D (15.92 ± 5.28 ng / mL), 31 - 40 years (15.33 ± 5.69 ng / mL) and > 40 years (14.13 ± 5.81 ng / mL) respectively which was statistically significant. (Table 2) Similarly, males had a higher mean vitamin D level (16.50 ± 5.25 ng / mL) in summer and (15.81 ± 5.01 ng / mL) in winter than females (12.69 ± 5.49 ng / mL and 11.92 ± 5.17 ng / mL respectively) (Table 2).

Parameters	Summer		Winter		P Value
	Mean ± SD	Min - Max	Mean ± SD	Min - Max	
Serum calcium (mg / dL)	9.02 ± 0.27	8.50 – 9.60	9.01 ± 0.26	8.50 – 9.60	0.096
Serum phosphorus (mg / dL)	3.88 ± 0.26	3.40 – 4.40	3.88 ± 0.27	3.40 – 4.50	0.167
Vitamin D (ng / mL)	15.14 ± 5.62	5.00 – 28.00	14.42 ± 5.38	5.00 – 26.00	< 0.001

Table 1. Comparison of Biochemical Parameters between Summer and Winter Seasons

Abbreviations: Min- minimum; Max- maximum

Based on occupation the mean vitamin D levels were higher in manual laborers as compared to the office workers irrespective of the seasons. (P < 0.001) (Table 2). Between dietary patterns followed, mean vitamin D level was higher among non-vegetarians (16.59 ± 5.70 ng / mL) as compared to vegetarians (12.54 ± 4.45 ng / mL) in summer and winter season (15.79 ± 5.46 ng / mL and 11.97 ± 4.31 ng / mL respectively) (P < 0.001) (Table 2). An increase in BMI showed significant decrease in the mean vitamin D levels in both the seasons (P < 0.01) (Table 2).

Among the 109 participants, 36 got exposed to < 1.5 hours, 50 got exposed to > 2.5 hours and 23 to 1.5 - 2.5 hours of sunlight. The Mean vitamin D level increased significantly across the three groups based on exposure to sunlight. Mean vitamin D was significantly higher in summer compared to winter in each exposure group with the exception of those exposed to 2 - 3 hours of sunlight (Table 2).

The prevalence of vitamin D deficiency was seen more in the age group of > 40 years (83.9 %), in 84.6 % of females, 92.3 % of vegetarians, 91.2 % of office workers, 100 % overweight individuals and 97.2 % of subjects exposed to less than 1.5 hours of sunlight in summer. The percentage of deficiency in the same factors increased in the winter season (Table 4).

The duration of exposure to sunlight showed that majority of the manual laborers (92.3 %) were exposed to > 2.5 hours of sunlight and 3.7 % of the office workers were exposed to > 2.5 hours. Majority of office workers (63.2 %) were exposed to < 1.5 hours of sunlight whereas none of the manual laborers were exposed to < 1.5 hours. The prevalence of vitamin D deficiency was 56 % in subjects exposed to > 2.5 hours in summer and 60 % in winter.

According to the Fitzpatrick classification there were only 2 in (type II), 14 in (type III), type IV (55), type V (31) and type VI (7), as the number was less in type II and type VI, they were clubbed into fair skinned (type II, III and type IV) and dark skinned (type V and VI). Vitamin D deficiency was equally prevalent in both fair and dark skin colour individuals irrespective of the season (78 %) (79 %) (Table 4).

		Age Groups	Summer		Winter		P Value
			Mean ± SD	Min - Max	Mean ± SD	Min - Max	
Vitamin D level (Nanogram / mL)		< = 30 years (n = 27)	15.93 ± 5.28	8.00 – 25.00	15.15 ± 4.90	8.00 – 23.00	< 0.001
		31 - 40 years (n = 51)	15.33 ± 5.69	6.00 – 26.00	14.57 ± 5.59	6.00 – 25.00	< 0.001
		> 40 years (n = 31)	14.13 ± 5.81	5.00 – 28.00	13.55 ± 5.81	5.00 – 26.00	0.002
		P Value	0.655		0.652		
Vitamin D level (Nanogram / mL)	Gender	Males (n = 70)	16.50 ± 5.25	7.00 – 28.00	15.81 ± 5.01	7.00 – 26.00	< 0.001
		Females (n = 39)	12.69 ± 5.49	5.00 – 28.00	11.92 ± 5.17	5.00 – 26.00	< 0.001
		P value	0.001		< 0.001		
Vitamin D level (Nanogram / mL)	Occupation	Manual Labourers (n = 52)	18.62 ± 4.69	9.00 – 28.00	17.67 ± 4.52	9.00 – 26.00	< 0.001
		Office Workers (n = 57)	11.96 ± 4.39	5.00 – 24.00	11.46 ± 4.29	5.00 – 22.00	< 0.001
		P value	< 0.001		< 0.001		
Vitamin D level (Nanogram / mL)	Diet	Vegetarians (n = 39)	12.54 ± 4.46	6.00 – 25.00	11.97 ± 4.31	6.00 – 24.00	< 0.001
		Non-Vegetarian (n = 70)	16.59 ± 5.70	5.00 – 28.00	15.79 ± 5.46	5.00 – 26.00	< 0.001
		P value	< 0.001		< 0.001		
Vitamin D level (Nanogram / mL)	Body mass index	Normal (n = 85)	16.40 ± 5.57	6.00 - 28.00	15.61 ± 5.32	6.00 - 26.00	< 0.001
		Overweight (n = 24)	10.67± 2.87	5.00 - 17.00	10.21 ±2.99	5.00 - 17.00	< 0.001
		P value	0.001		< 0.001		
Vitamin D level (Nanogram / mL)	Hours of exposure to sunlight	< 1.5 hours (n = 36)	10.00 ± 2.99	5.00 – 20.00	9.36 ± 2.74	5.00 – 19.00	< 0.001
		1.5 – 2.5 hours (n = 23)	14.61 ± 3.95^{a*}	8.00 – 23.00	14.30 ± 3.82^{a*}	8.00 – 21.00	0.166
		> 2.5 hours (n = 50)	19.08 ± 4.56^{b*c*}	10.00 –28.00	18.12 ± 4.37^{b*c*}	9.00 – 26.00	< 0.001
		P value	< 0.001		< 0.001		

Table 2. Comparison of Risk Factors on Vitamin D Status between Summer and Winter Seasons

Skin Type	Vitamin D Levels	
	Summer	Winter
Fair skinned	15.55 ± 5.78 a** (5.00 – 28.00)	14.81 ± 5.43 (5.00 – 26.00)
Dark skinned	15.63 ± 5.37 a** (8.00 – 26.00)	14.74 ± 5.37 (7.00 – 25.00)

Table 3. Comparison of Vitamin D Levels Based on Season and Skin Type

a, comparison of Vitamin D levels between two seasons and within the same skin type
b, comparison of Vitamin D levels between the skin types and within the same season
*, P < 0.05; **, P < 0.01

No significant association was seen between vitamin D status and skin type in both seasons (Table 3). Vitamin D levels in summer showed a positive and strong correlation with vitamin D levels among fair skinned as well as dark skinned subjects. Vitamin D levels in summer and winter correlated better with hours of exposure in dark skinned than in fair skinned subjects (Table 5).

Vitamin D sufficiency was seen more in subjects whose face, hand, leg and feet were exposed to sunlight irrespective of skin type, 100 % vitamin D deficiency was seen in group V, group IV and group III subjects, irrespective of the season. Hence, significant association was seen between Vitamin D status and area exposed in both seasons. (P < 0.001). (Table 4)

Age Groups		Vitamin D Status Summer Deficiency	Summer Sufficiency	Winter Deficiency	Winter Sufficiency
Based on age groups	< = 30 years (n = 27)	70.4 % (19)	29.6 % (8)	74.1 % (20)	25.9 % (7)
	31 - 40 years (n = 51)	74.5 % (38)	25.5 % (13)	76.5 % (39)	23.5 % (12)
	> 40 years (n = 31)	83.9 % (26)	23.9 % (5)	87.1 % (27)	12.9 % (4)
	P value	0.452		0.405	
Based on gender	Males (n = 70)	71.4 % (50)	28.6 % (20)	74.3 % (52)	25.7 % (18)
	Females (n = 39)	84.6 % (33)	15.4 % (6)	87.2 % (34)	12.8 % (5)
	P value	0.122		0.114	
Based on body mass index	Normal (n = 85)	69.4 % (59)	30.6 % (26)	72.9 % (62)	27.1 % (23)
	Overweight (n = 24)	100 % (24)	0 % (0)	100 % (24)	0 % (0)
	P value	0.001		0.002	
Based on diet	Vegetarian (n = 39)	92.3 % (36)	7.7 % (3)	94.9 % (37)	5.1 % (2)
	Non vegetarian (n = 70)	67.1 % (47)	32.9 % (23)	70.0 % (49)	30.0 % (21)
	P value	0.003		0.002	
Based on occupation	Manual labourers (n = 52)	59.6 % (31)	40.4 % (21)	63.5 % (33)	36.5 % (19)
	Office workers (n = 57)	91.2 % (52)	8.8 % (5)	93.0 % (53)	7.0 % (4)
	P value	< 0.001		< 0.001	
Hours of exposure to sunlight	< 1.5 hours (n = 36)	97.2 % (35)	2.8 % (1)	100 % (36)	0 % (0)
	1.5 – 2.5 hours (n = 23)	87.0 % (20)	13.0 % (3)	87.0 % (20)	13.0 % (3)
	> 2.5 hours (n = 50)	56.0 % (28)	44.0 % (22)	60.0 % (30)	40.0 % (20)
	P value	< 0.001		< 0.001	
Skin type	Fair skinned n = 71	55 (78 %)	16	56 (79 %)	15
	Dark skinned n = 38	30 (79 %)	8	31(81 %)	7
	P Value	0.859		0.737	
Body surface area exposed	Face, Arm, Leg, Feet (n = 28)	16 (57 %)	12	18 (64 %)	10
	Face, Arm, Feet (n = 32)	20 (62.5 %)	12	20 (62.5 %)	12
	Face, Arm (n = 24)	24 (100 %)	0	24 (100 %)	0
	Face, Feet (n = 6)	6 (100 %)	0	6 (100 %)	0
	Face (n = 19)	19 (100 %)	0	19 (100 %)	0
	P Value	< 0.001		< 0001	

Table 4. Prevalence of Vitamin D Status on Risk Factors in Both Seasons

Correlations Skin Colour			Vitamin D (Summer)	Vitamin D (Winter)	HRS of Exposure
Fair skinned	Vitamin D (summer)	Pearson Correlation	1	.988**	.640**
		Sig. (2-tailed)		.000	.000
		N	71	71	71
	Vitamin D (winter)	Pearson Correlation	.988**	1	.645**
		Sig. (2-tailed)	.000		.000
		N	71	71	71
	HRS of exposure	Pearson Correlation	.640**	.645**	1
		Sig. (2-tailed)	.000	.000	
		N	71	71	71
Dark skinned	Vitamin D (summer)	Pearson Correlation	1	.989**	.748**
		Sig. (2-tailed)		.000	.000
		N	38	38	38
	Vitamin D (winter)	Pearson Correlation	.989**	1	.765**
		Sig. (2-tailed)	.000		.000
		N	38	38	38
	HRS of exposure	Pearson Correlation	.748**	.765**	1
		Sig. (2-tailed)	.000	.000	
		N	38	38	38

Table 5. Correlation between Vitamin D Levels in Both Seasons and Hours of Exposure Based on Skin Colour

**. Correlation is significant at the 0.01 level (2-tailed).

Area Exposed	Vitamin D Levels Summer	Winter
Face, arm, leg, feet (group I)	19.50 ± 4.12 a **, b, c**, d*, e** (12.00 – 28.00)	18.57 ± 3.99 b, c**, d*, e** (10.00 – 26.00)
Face, arm, feet (group II)	18.88 ± 4.38 a**, f**, g*, h** (12.00 – 28.00)	17.89 ± 4.21 f**, g*, h** (10.00 – 26.00)
Face, arm (group III)	12.29 ± 4.03 a*, i, j (5.00 – 20.00)	11.71 ± 4.02 i, j (5.00 – 19.00)
Face, feet (group IV)	12.67 ± 4.18 k (8.00 – 19.00)	12.33 ± 3.20 k (9.00 – 17.00)
Face (group V)	9.32 ± 1.83 a* (6.00 – 14.00)	8.64 ± 1.43 (6.00 – 12.00)

Table 6 Comparison of Vitamin D Levels Based on Season and Area Exposed

All subjects with the exception of only face and feet exposed to sunlight, showed higher mean Vitamin D levels during summer compared to winter. Subjects whose face, hand, legs and feet were exposed to sunlight showed higher levels of vitamin D. There was no significant difference in mean vitamin D levels between group I and II, group III and IV, group III and V and group IV and V. (Table 6)

- Comparison of vitamin D levels between two seasons and within the same skin type,
- Comparison of vitamin D between group I and II within the same season,
- Comparison of vitamin D between group I and III
- Comparison of vitamin D between group I and IV
- Comparison of vitamin D between group I and V
- Comparison of vitamin D between group II and III
- Comparison of vitamin D between group II and IV,
- Comparison of vitamin D between group II and V,
- Comparison of vitamin D between group III and IV,
- Comparison of vitamin D between group III and V,
- Comparison of vitamin D between IV and V.

*, P < 0.05; **, P < 0.01

DISCUSSION

This study was conducted on 109 apparently healthy subjects residing in Mangalore. This region receives maximum sunlight throughout the year with three main seasons; summer, monsoon and winter. The mean vitamin D level in the total population was higher in summer as compared to winter in our study which was also observed in studies done by S.N Saeidlou[9] and R. Sabharwal.[10] During summer, the percentages of subjects in the total population with Vitamin D deficiency were 76.1 %, the deficiency increased by 2.8 % during winter season which went along with a study carried out in the city of Sao Paulo, Brazil by Sergio S M et al.[11]

There are studies which show that females are more vitamin D deficient than males which is similar to our study wherein 84.6 % of females exhibited deficiency in summer and 87.2 % in winter. The mean serum vitamin D level in our female population was lower when compared to males irrespective of the seasons. An Iranian study too concluded the same results showing a greater female preponderance. This could be due to limited exposure to sunlight, more coverage of skin in females and nature of their jobs causing less physical activity.[12]

N. Binkley showed low vitamin D level in subjects even after adequate sun exposure.[13] The association of sunlight exposure and vitamin D levels was evaluated in the current study. The duration of exposure to sunlight in 92.3 % of manual laborers was > 2.5 hours whereas only 3.7 % of the office workers were exposed to > 2.5 hours. 63.2 % of the office workers were exposed to < 1.5 hours of sunlight while none of the manual laborers had such a short exposure to sunlight. The mean vitamin D level increased as the hours of exposure increased, it was statistically higher in > 2.5 hours of exposure (19.08 ± 4.56 ng / mL) and (18.12 ± 4.37 ng / mL) in both the seasons. The mean serum vitamin D level in office workers was 11.96 ± 4.39 ng / mL whereas in manual laborers it was 18.62 ± 4.69 ng / mL, thus statistically higher in manual laborers when compared to the office workers. This was similar to studies done by G. Munter et al.[14] The duration of exposure to sunlight remained the same in both the seasons as majority of the manual laborers were construction workers and their Job forced them to get exposed to the said duration. The prevalence of vitamin D deficiency was 56 % in those who were exposed to the sun for > 2.5 hours and 97.2 % in those who were exposed for < 1.5 hours, thus indicating the increase in vitamin D levels with the increase of exposure to the sun and increase of physical activity as compared to the sedentary lifestyle of the office workers. In the current study, the prevalence of vitamin D deficiency was higher among office workers. Al-Anouti et. al. showed similar results with 63.2 % having severe deficiency, 29.1 % deficiency and 5.7 % sufficiency among indoor workers.[15] which was similar to a pilot study done by Rai T et al.[16] This may be attributed to the fact that they spent most of the morning and afternoon hours indoors, which is the ideal time for optimal Vitamin D production.

Non-vegetarians had statistically higher vitamin D levels (16.59 ± 5.70 ng / mL) than vegetarians (12.54 ± 4.45 ng / mL). The prevalence of deficiency was higher in vegetarians. Animal sources are the richest source of vitamin D with milk being the only source of vitamin D in vegetarians. Vegetarian diet contains high amount of phytates which chelate micronutrients and hence reduce their absorption.[17] Diet is not a major source of vitamin D and socio-economic status plays a crucial role in dietary food habits, prohibiting the manual laborers to cook non-vegetarian food daily and buy food items fortified with vitamin D supplements.

Once vitamin D gets absorbed, it is distributed to adipose and other tissues and therefore availability of vitamin D in obese individuals' decreases as all the compartments are increased in obese people. Subcutaneous adipose tissue also suppresses the enzyme for hydroxylation of vitamin D.[18] In our study the prevalence of vitamin D deficiency was highest among overweight individuals. This finding is supported by a study carried out by N. Dressler et al.[19]

Astonishingly vitamin D deficiency in our study was more prevalent in fair skinned individuals as well as dark skinned individuals irrespective of the season as negating the melanin influence on vitamin D synthesis in this population. This finding is unique and differ with many studies that conclude dark skinned individuals are more often predisposed to vitamin D deficiency.[20] However one study showed no difference in vitamin D levels after increase in UVB exposure in both dark skinned and fair skinned individuals,[21] whereas in our present study vitamin D levels correlated better with hours of exposure in dark skinned individuals in both the seasons. These findings are positive as majority of them were manual laborers and had maximum body exposure (face, arms, legs and feet) to sunlight which is pragmatic and the majority of the fair skinned group belonged to the office workers who mostly stayed indoors with minimum body surface area exposure.

Skin surface area exposure to sunlight is a confounding factor which is reflected in the current study with 100 % vitamin D deficient rate in individuals with exposure of only face, face and feet and face and arms to sunlight and rate of deficiency descended as the exposure of body surface area increased, which was the case in many other such studies.[22] As vitamin D is synthesised by UVB radiation falling on the epidermal layer of the skin, converting 7-dehydrocholesterol to vitamin D3, larger the area of skin exposed more will be the production of vitamin D as observed by Osmancevic et al.[23] A study by Nadine jager et al. displayed sufficient amount of vitamin D production with partial body surface exposed around 10 % (face and hands) and moderate UV dose.[24] Significant association was seen between vitamin D status and area exposed in both seasons (P < 0.001).

CONCLUSIONS

Vitamin D deficiency was statistically more common in winter than in summer. It was seen correlating with majority of the risk factors, except skin colour. Among the confounding factors the key for vitamin D production in this population was maximum body surface area exposure (face, hands, legs and feet) to sunlight for more than 2.5 hours irrespective of the skin tone which is rather impractical due to occupational constraints and ethnic issues. However, majority of the population was vitamin D deficient yet did not manifest with any skeletal or extra skeletal morbidity. Thus, a reliable cut off reference levels should be set in this population.

Limitations
An exclusive diet history was not highlighted, and a small sample size was taken keeping the limited budget in mind as two seasons were considered.

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