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Geographic and Seasonal Variation of Vitamin D: A Retrospective Study in Two Centers of Nepal

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ABSTRACT

Background: Vitamin D deficiency is a common problem in many countries throughout the world. This study aimed at understanding the status of vitamin D deficiency in relation to age, gender, geography and season among relatively bigger numbers of population residing in central and western regions of Nepal.

Methods: This retrospective cross-sectional study was carried out by reviewing the records of vitamin D tests in two centers of Nepal- namely united reference laboratories at Pokhara and Chitwan Medical College at Chitwan. A total of 3320 individuals who were tested for clinical suspicion of vitamin D deficiency over a period of one year were included in the study.

Results: Mean vitamin D level was 18.7 ng/mL. Majority of subjects tested for vitamin D were females (71.36 %) with female to male ratio of 2.49:1. Hypovitaminosis D (≤ 30 ng/mL) was found in 84.5% subjects and was moderate to severely deficit (<10 ng/mL) in 25.9% of subjects. Status of hypovitaminosis D was found to be less in ≥50 years (79.9%) than the younger subjects (89.9% in ≤18 years and 87.0% in 19-49 years age group). Vitamin D deficiency was found lower in hills districts (80.8% vs 89.7% in the plains), which was found to be more pronounced during winter through summer seasons as compared to fall season.

Conclusions: Population residing in plain areas and summer, spring and winter season are found to have increased problem of Hypovitaminosis D. It is also found to be common among younger children and female of reproductive age group. We have also found out the increased problem of hypovitaminosis D among population residing in the plain areas than in the hills especially in the summer, spring and winter season.

Keywords: Geographic variation; hypovitaminosis D; Nepal

INTRODUCTION

Vitamin D has an important role in maintenance of homeostasis.[1,2] The level of Vitamin D can vary according to the age group,[3,4] season[5,6] and geographic distribution.[7]

There is a paucity of data on prevalence of vitamin D deficiency in national level but different community and hospital-based studies have reported the status of vitamin D deficiency as a common public health problem in Nepal.[8, 9] The prevalence of Vitamin D deficiency has been reported to be ranged between 73% and 89% among adult population[8,9] and 4.2% to 91.1% among pediatric population.[10] There is a lack of evidence on comparison of vitamin D among individuals residing in different geographic locations of Nepal. This retrospective study aims at understanding the status of vitamin D deficiency in relation to age, gender, geography and season among relatively bigger numbers of population residing in central and western regions of Nepal.

METHODS

A retrospective cross-sectional study was carried out by reviewing the records of vitamin D tests in two centers of central and western part of Nepal - namely Chitwan Medical College (CMC) Bharatpur, Chitwan, and United Reference Laboratories (URL), Pokhara, Kaski. CMC is centrally located in the plain area while URL is located in the middle hills in western region. By their geographic proximity, majority of the patients visiting CMC and URL came from the plains and hill districts respectively.

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Ethical clearance was obtained from the Institutional Review Committee (IRC) of Chitwan Medical College before initiation of the study. Those individuals who were tested for clinical suspicion of vitamin D deficiency over a period of one year between 1st January and 30th December 2017 were included in the study. A total of 3320 individuals were tested (1658 at CMC, Chitwan and 1662 at URL, Pokhara) for vitamin D level.

Serum levels of total 25-hydroxy vitamin D were estimated by using electrochemiluminescence (ECLIA) method (either by ADVIA Centaur vitamin D total assay by Siemens Healthcare Diagnostics, Erlangen, Germany or by Cobas e411 Roche Diagnostics, Mannheim, Germany).

Following the United States endocrine society classification[4] subjects were divided into 4 groups on the basis of vitamin D level - (1) Sufficient: >30 ng/mL (2) Insufficiency: 21 to 29 ng/mL (3) Mild deficiency: 10 to 20 ng/mL and (4) Moderate to severe deficiency: <10 ng/mL. In the aggregate analysis we have used the term hypovitaminosis to indicate any form of insufficiency or deficiency of vitamin D with a value of less than 30 ng/mL.

Data analysis was done by using SAS University Studio package. Results of the study were expressed in frequency and percentage. One-way analysis of variance (ANOVA) was used to compare vitamin D levels in male versus female and between different age groups. Data with P value <0.05 were considered to be significant.

RESULTS

The mean±SD vitamin D level was 18.7±12.0 (median 16.7) ng/mL with highest and lowest recorded values of 85.9 ng/mL and 1.9 ng/mL respectively. Majority of subjects tested for vitamin D were females (71.36 %,) with female to male ratio of 2.49:1. Upon segregation, the mean±SD vitamin D level in the males and females was 19.6±12.6 (median 16.8) and 18.9±12.4 (median 16.17) ng/mL respectively. The overall vitamin D sufficiency (>30 ng/mL) and hypovitaminosis D (≤30 ng/mL) was found in 15.5% and 84.5% subjects respectively. It was insufficient (20-29 ng/mL) in 21.9%, mildly deficit (10-19 ng/mL) in 36.8% and moderate to severely deficit (<10 ng/mL) in 25.9% of subjects (Table 1).

Status of hypovitaminosis D was found to be less in ≥50 years of age (79.9%) in comparison to the younger subjects (89.9% in ≤18 years and 87.0% in 19-49 years age group). Moderate to severe deficiency was seen in 34.8% of subjects aged below 19 years, 27.8% in 19-49 years and 21.5% in ≥50 years.

The districts were broadly classified into hills and plains based on the overall geography of the area. Hypovitaminosis D was found lower in hills districts (80.8% versus 89.7%). Highest proportion of moderate to severe deficiency was found in plains (37.2%).

The level of vitamin D status of the subjects were analyzed by months and seasons of the year. Highest number of samples came from January (17.1%) and February (16.1%) while the lowest number of testing were done in June (4.1%) and May (3.6%).

The months were grouped into four seasons: winter (December-February), spring (March-May), summer (June-August) and fall (September-November). Hypovitaminosis D was found to be more pronounced during winter through summer seasons (Winter: 86.1%; Spring: 85.7%; Summer: 86.7%) as compared to 77.1% in Fall season (Table 2). In terms of the severity, highest frequency of moderate to severe deficiency of vitamin D was found in Summer (32.1%) followed by Spring (28.9%), Winter (25.1%) and Fall (18.3%); p=<0.001.

Table 1. Levels of vitamin D sufficiency status by age, gender and geographic location.

Variable	Values	Sufficient (≥30 ng/mL)	Insufficient (20-29 ng/mL)	Mild Deficit (10-19 ng/mL)	Moderate to Severe Deficit (<10 ng/mL)	p-value
		n (%)	n (%)	n (%)	n (%)	
Gender	Female	335 (14.1%)	504 (21.3%)	871 (36.8%)	659 (27.8%)	<.0001
	Male	178 (18.7%)	223 (23.4%)	350 (36.8%)	200 (21.0%)	
Age group (in years)	≤18	18 (10.1%)	29 (16.3%)	69 (38.8%)	62 (34.8%)	<.0001
	19- 49	251 (13.0%)	412 (21.3%)	734 (38.0%)	537 (27.8%)	
	≥50	244 (20.2%)	286 (23.7%)	418 (34.6%)	260 (21.5%)	
Geography	Hills	369 (19.2%)	469 (24.4%)	742 (38.7%)	338 (17.6%)	<.0001
	Plains	144 (10.3%)	258 (18.4%)	479 (34.2%)	521 (37.2%)	
Overall		513 (15.5)	727 (21. 9%)	1221 (36.8%)	859 (25.9%)	

Table 2. Levels of vitamin D sufficiency by season.

Season	Sufficient (≥30 ng/mL)	Insufficient (20-29 ng/mL)	Mild Deficit (10-19 ng/mL)	Moderate to Severe Deficit (<10 ng/mL)	p-value
	N (%)	N (%)	N (%)	N (%)	
Fall	136 (22.9%)	132 (22.2%)	218 (36.6%)	109 (18.3%)	<0.001
Spring	79 (14.3%)	116 (21.1%)	197 (35.8%)	159 (28.9%)	
Summer	85 (13.3%)	125 (19.5%)	225 (35.1%)	206 (32.1%)	
Winter	213 (13.9%)	354 (23.1%)	581 (37.9%)	385 (25.1%)	
Overall	513 (15.45)	727 (21.89%)	1221 (36.79%)	859 (25.87%)	

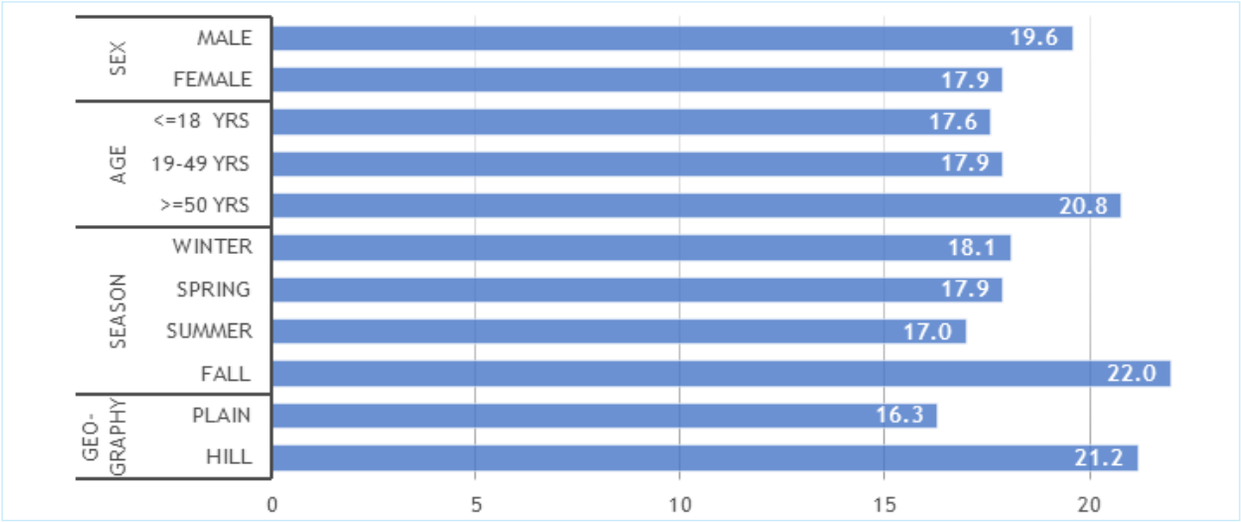

Figure 1. Regression adjusted mean vitamin D test scores.

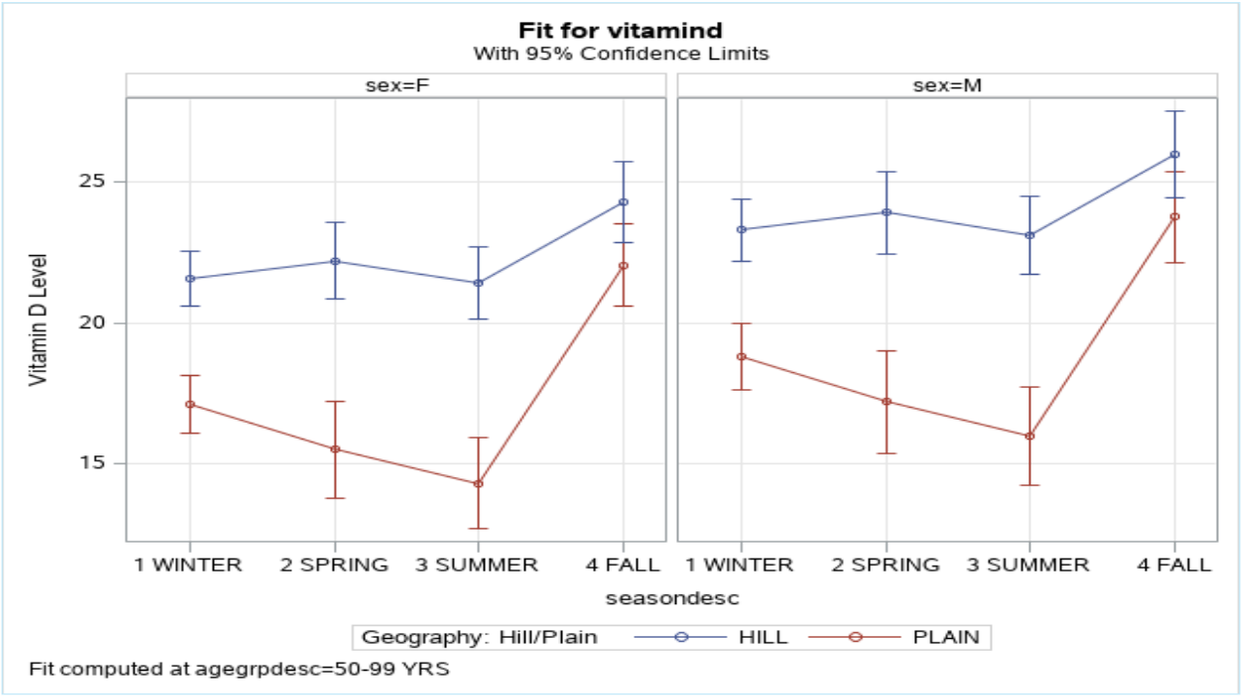

Figure 2. Geography and seasonal effect on adjusted vitamin D score.

As the categories of vitamin D levels were significant when tested individually against age, gender, geography and seasons, we also analyzed the vitamin D level as a continuous variable using ANOVA and adjusting for all these variables together. Figure 1 shows higher vitamin D scores associated with living in hill districts, during the fall season (base=winter), among men and people 50 years and older (base=1-18 years), all significant at p<.0001. However, the adjusted means were not statistically different between below 1-18 years and 19-49 years age group as well as among winter, spring and summer seasons.

We suspected there may be some differences in the predicted vitamin D level between hills and plain during different seasons. An interaction variable between geography and season was introduced in the ANOVA model. Predicted values (Fit results) were presented for each season plotted by geography and sex for a 50-99 years group (Figure 2). The differences in predicted vitamin D levels in hill versus plain is clearly different by seasons. The figure shows that predicted vitamin D level is always high in hills as compared to plains and male have slightly higher vitamin D level as compared to female in all seasons and both geography (left vs right figure). The overlapping 95% confidence interval of two ends in the graphics show that hill vs plain difference in fall season is not statistically significant. The winter, spring and summer seasons have significantly lower predicted values of vitamin D level in the plains as compared to the hills. Additionally, the changes in vitamin D level across season is much smaller in the hills whereas it dropped quite remarkably in the plains, falling continuously in winter, spring and summer before peaking up in the fall for both genders in the included age group.

DISCUSSION

This was a cross sectional retrospective study that examined the status of vitamin D level among individuals who were tested for clinical suspicion of its deficiency. The overall percentage of hypovitaminosis D (vitamin D levels <30 ng/ml) in this study was 84.5%, of which 25.9% had moderate to severe deficiency (<10 ng/mL). High percentage of hypovitaminosis D in our study population can be attributed to limited outdoor activity and skin pigmentation that is further compounded by air pollution and traditional clothing. This finding is comparable to other studies done in different spectrum of population in India.[11, 12] Bhatta et al reported vitamin D deficiency in 73.68% of individuals in western region of Nepal.[8] However, our finding is higher than few other studies, in which the reported prevalence of vitamin D deficiency/insufficiency ranged between 23.2 to 25.8%.[13, 14] The relatively higher prevalence of hypovitaminosis D in our study could be because of the fact that we included those subjects who attended the clinics for some medical problems and had clinical suspicion of the deficiency.

The level of vitamin D was lower in the females (18.9±12.4 ng/mL) than the males (19.65±12.6 ng/mL). This finding could be attributable to the social practice where females are involved in more indoor household activities with less exposure to sunlight than the males.

In contrary to few other studies,[15, 16] in our study almost 90% of individuals below the age of 18 years had hypovitaminosis D and 34.8% had severe deficiency. The phenomenon of lower vitamin D levels in younger age was also observed in both sexes, making it less likely that the observation was simply a chance finding. Rapid urbanization has limited the outdoor activities among the growing children with less exposure to sunlight, which might play a pivotal role to create problems in overall physical and intellectual growth and development of this vulnerable group of population. This finding urges the need of vitamin D supplementation especially to the pregnant ladies and growing children. Till date, there is no practice of fortification of milk or other food items with vitamin D in Nepal. So, the only chief source of vitamin D is the exposure to sunlight.

Adjusted vitamin D level was lower among the subjects residing in the plains than those in the hills that could have multi factorial etiopathogenesis. People residing in plains would have tendency to avoid exposure to sunlight as far as possible. Thus, there is a relatively short window of opportunity to produce vitamin D_3 in the skin. Another hypothetical factor for lower levels of vitamin D in the plain areas, though we did not look upon in our study, could be the higher prevalence of melanin pigmentation of the skin among the people residing in the plain areas.

Significant association between season and vitamin D level and its deficiency has been found out in different parts of the world.[17, 18] In our study, 86.7% subjects in summer had hypovitaminosis D, and 32.1% had moderate to severe deficiency. Least proportion of deficiency was noted during fall season (77.1%) with only 18.3% of subjects having severe deficiency. Among the subjects residing in the hills, vitamin D level is almost in the same range across all seasons whereas in the plain areas, the problem of hypovitaminosis is more pronounced during summer, spring and winter with better level in the fall. Predicted vitamin D level was always high in hills as compared to plains and male have slightly higher vitamin

D level as compared to female in all seasons and both geography The reason behind such seasonal variation in two geographic areas in our population could be attributable to limited outdoor activities and exposure to sunlight due to relatively higher temperature in the summer especially in the plain areas. Even if they go outside home, people tend to use umbrella or remain under the shades of the trees. The outdoor temperature and environment become pleasant during the fall and people would love to be exposed to the sunlight creating favorable condition for vitamin D synthesis. The direct interaction between geographic areas and seasonal variation would suggest the development and modification of policies to implement oral supplement of vitamin D in the plain areas during the months of extreme heat.

CONCLUSIONS

We have also found out the increased problem of hypovitaminosis D among population residing in the plain areas than in the hills especially in the summer, spring and winter season. Present study has concluded that vitamin D deficiency is a common problem among Nepalese population, especially in the younger children and females of reproductive age group.

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