

# Vitamin D levels of anesthesiologists working in tertiary care hospital of South Asian country: An observational study

Sonika Bishnoi, Satinder Gombar, Vanita Ahuja, Neerja Bhardwaj<sup>1</sup>, Jaspinder Kaur<sup>2</sup>

Department of Anesthesia and Intensive Care, Government Medical College and Hospital, <sup>1</sup>Department of Anesthesia and Intensive Care, Post Graduate Institute of Medical Education and Research, <sup>2</sup>Department of Biochemistry, Government Medical College and Hospital, Chandigarh, India

## Abstract

**Background and Aims:** Vitamin D deficiency is now emerging as a major global health problem. Doctors spend most of their time indoors and hence, have very low sun exposure. With limited studies on vitamin D levels of anesthesiologists and no published study from South Asian countries, we planned to determine vitamin D levels in anesthesiologists.

**Material and Methods:** One hundred twenty anesthesiologists, working in two tertiary care hospitals, were enrolled in this study. The participants were asked to complete the questionnaire and blood samples were drawn at the same sitting for measuring serum 25(OH) D and serum calcium levels. A subgroup analysis of anesthesiologists was done based on vitamin D status levels defined as per Endocrine society clinical practice guidelines 2011 on vitamin D deficiency. Vitamin D deficiency: 25(OH) D <20 ng/ml (<50 nmol/l), Vitamin D insufficiency: 25(OH) D of 21–29 ng/ml (52.5–72.5 nmol/l), Vitamin D sufficiency: 25(OH) D of ≥30 ng/ml (≥75 nmol/l).

**Results:** The mean working hours in a day [mean ± standard deviation (SD)] were 10.70 ± 1.56 hours with a range of 8–15 hours. The mean ± SD level of vitamin D in anesthesiologists was 14.56 ± 9.39 ng/ml with a range of 5.30–58.00 ng/ml. Out of 120 anesthesiologists, 101 (84.2%) anesthesiologists had deficient levels of vitamin D, 10 (8.3%) had insufficient levels, and 9 (7.5%) anesthesiologists had sufficient levels of vitamin D. Majority of the anesthesiologists had normal serum calcium levels. A total of 91.5% of doctors had vitamin D deficiency who were not taking vitamin D supplement groups as compared to 28.6% in doctors who had taken vitamin D supplements in the past.

**Conclusion:** Prevalence of vitamin D deficiency/insufficiency was high among anesthesiologists. However, levels were optimal in professionals taking vitamin D supplements

**Keywords:** Anesthesiologists, risk factors, Vitamin D Deficiency

## Introduction

Vitamin D (calciferol) is a pro-hormone, synthesized approximately 80% in skin and a smaller amount is derived from the diet. The other factors which can influence vitamin D levels are age, race, sunscreen application, medication, and malabsorption conditions.<sup>[1]</sup>

Deficiency of Vitamin D leads to skeletal complications includes defective bone mineralization leading to osteopenia, osteoporosis, and muscle weakness. Extraskelatal complications include risk of cardiovascular disease, diabetes mellitus, autoimmune disease, schizophrenia and depression, adverse obstetric, and newborn outcome.<sup>[2-5]</sup>

Address for correspondence: Dr. Vanita Ahuja,  
Department of Anaesthesia and Intensive Care, Government Medical  
College and Hospital Chandigarh, India.  
E-mail: vanitaanupam@yahoo.co.in

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow\_reprints@wolterskluwer.com

Access this article online	
Quick Response Code:	Website: www.joacp.org
	DOI: 10.4103/joacp.JOACP_310_19

**How to cite this article:** Bishnoi S, Gombar S, Ahuja V, Bhardwaj N, Kaur J. Vitamin D levels of anesthesiologists working in tertiary care hospital of South Asian country: An observational study. *J Anaesthesiol Clin Pharmacol* 2021;37:237-42.

Submitted: 20-Sep-2019

Revised: 14-Mar-2020

Accepted: 20-Mar-2020

Published: 15-Jul-2021

Vitamin D deficiency is now emerging as a major global health issue and has been reported in medical students.<sup>[5-7]</sup> The working hours of the anesthesiologists usually start early in the morning and continue till the late evening hours. These working areas are mostly confined to indoors. The windows in the operation theatres and intensive care units do not allow enough ultraviolet B light to penetrate. In a study from India, the time of adequate sun exposure was reported to be between 11 AM and 2 PM and the absence of sun exposure during this time may decrease the synthesis of vitamin D.<sup>[8]</sup> Even after night duty, sleep deprivation causes daytime sleepiness which also leads to inadequate sun exposure. With limited studies on vitamin D levels of anesthesiologists and no published study from South Asian countries, we planned to determine vitamin D levels in anesthesiologists.

## Material and Methods

This prospective, cross-sectional, observational trial was conducted in two tertiary care centers. An approval of the institutional ethical committee was obtained from Government Medical College and hospital, Chandigarh IEC Regd.no. ECR/658/Inst/PB/2014 dated 01.12.2017 and Post Graduate Institute of Medical Education and Research, Chandigarh (INT/IEC/2018/000282). The trial was registered with Clinical Trials Registry India (CTRI/2018/02/011805). We enrolled 120 anesthesiologists from both the institutes during the period March 2018–May 2018 and written informed consent was taken.

The anesthesiologists with the following conditions were excluded; metabolic bone disease, history of the parathyroid disorder, drugs affecting vitamin D metabolism (anticonvulsants, glucocorticoids, ketoconazole, anti-retroviral drugs), history of liver disease, history of renal disease, history of gastrointestinal disease, pregnancy, and lactation.

The participants were asked to complete the questionnaire about their demographics, professional working duration, lifestyle, and dietary characteristics.<sup>[9]</sup> After that, the blood sample was taken for measuring serum 25(OH) D and serum calcium levels. For all participants, non-fasting blood sample was taken during the day. A subgroup analysis of anesthesiologists was done on the basis of vitamin D status levels defined as per Endocrine society clinical practice guidelines 2011 on vitamin D deficiency. Vitamin D deficiency: 25(OH) D <20 ng ml<sup>-1</sup> (<50 nmol l<sup>-1</sup>), Vitamin D insufficiency: 25(OH) D of 21–29 ng ml<sup>-1</sup> (52.5–72.5 nmol l<sup>-1</sup>), Vitamin D sufficiency: 25(OH) D of ≥30 ng ml<sup>-1</sup> (≥75 nmol l<sup>-1</sup>).<sup>[10]</sup>

The vitamin D levels in the samples were measured by chemiluminescence assay, which was used for *in vitro* diagnostic use in the quantitative determination of 25 (OH) D in human serum using ADVIA Centaur XP chemiluminescence (Siemens Healthineers, Siemens Medical Solutions, PA, USA). Serum calcium was measured on the Random Access Chemistry analyzer (Roche Diagnostics model P-800, Rotkreuz, Switzerland) using the standard method.

Statistics: The sample size was estimated based on the assumption that 50% of subjects were deficient of vitamin D.<sup>[11]</sup> To estimate this proportion with a 95% confidence interval of proportion and margin of error as 10%, the sample size required was 96 subjects using the formula

$$n_0 = (z)^2 * (p)(q) / (d)^2$$

Where:  $n_0$  is the sample size;  $z$  is the value for the selected alpha level, e.g., 1.96 for (0.05) i.e., at 95% confidence level.  $P$  is the estimated proportion of an attribute that is present in the population. In the equation,  $q$  is  $1-p$ ,  $d$  is the acceptable margin of error for proportion being estimated (we have taken 10%), for possible attrition and so, we decided to include 120 participants.

Discrete categorical data were presented as  $n$  (%). Continuous data were written as either in the form of its mean and standard deviation or in the form of its median and interquartile range, as per the requirement. The Normality of quantitative data was checked by measures of Kolmogorov–Smirnov tests of Normality. For Normally distributed data, a t-test was applied and for skewed data, nonparametric Mann–Whitney  $U$ -test was used for statistical analysis. For categorical data, comparisons were made by Pearson Chi-square test or Fisher's exact test as appropriate. All the statistical tests were performed at a significance level of  $\alpha = 0.05$ . Analysis was conducted using IBM Statistical Package for the Social Sciences (SPSS) STATISTICS (version 22.0).

## Results

In this study, 125 anesthesiologists were screened, out of these 5 refused to take part so 120 anesthesiologists were evaluated for demographics, professional working duration, lifestyle, and dietary characteristics. Subgroup analysis of anesthesiologist was done on the basis of vitamin D status levels defined as per Endocrine society clinical practice guidelines 2011.<sup>[9]</sup>

Anesthesiologist's demographic characteristics are shown in Table 1. The primary aim of the study was to study vitamin D levels in anesthesiologists. The mean  $\pm$  SD level of vitamin D

in anesthesiologists was  $14.56 \pm 9.39 \text{ ng.ml}^{-1}$  with a range of  $5.30\text{--}58.00 \text{ ng.ml}^{-1}$ .

Out of these 120 anesthesiologists, 101 (84.2%) anesthesiologists had deficient levels of vitamin D, 10 (8.3%) had insufficient levels, and 9 (7.5%) anesthesiologists had sufficient levels of vitamin D [Figure 1]. The mean  $\pm$  SD vitamin D level of anesthesiologists found to be deficient, insufficient, and sufficient levels were  $11.10 \pm 3.23 \text{ ng ml}^{-1}$ ,  $25.66 \pm 3.02 \text{ ng ml}^{-1}$ , and  $41.00 \pm 8.88 \text{ ng ml}^{-1}$ , respectively [Figure 2].

The median (interquartile range) work duration (in months) in anesthesia were 36 (18-51.5 [9 – 408]). The association between the professional work duration of anesthesiologist and vitamin D status was statistically significant ( $p = 0.005$ ). No statistically significance was found between sun exposure and vitamin D status ( $P = 0.668$ ). The mean working hours in a day (mean  $\pm$  SD) were  $10.70 \pm 1.56$  hours with a range of 8–15 hours. The working hours as per subgroup analysis were similar in all the groups, and was found to be statistically insignificant ( $P = 0.684$ ) [Table 2].

The mean body mass index (BMI) of anesthesiologists (mean  $\pm$  S.D) was  $24.34 \pm 3.42 \text{ kg m}^{-2}$ . The difference in mean BMI of all anesthesiologists on subgroup analysis was statistically not significant ( $p = 0.338$ ). There was a significant association between multivitamin intake and vitamin D status ( $P = 0.005$ ), and vitamin D supplementation and vitamin D status ( $P = < 0.001$ ). There was no significant association between other objectives and vitamin D status—sunscreen use ( $P = 0.707$ ), sun exposure ( $P = 0.688$ ), milk intake ( $P = 0.403$ ), egg intake ( $P = 0.461$ ), non-vegetarian diet intake ( $P = 0.166$ ), and symptoms ( $P = 0.760$ ) [Figure 3]. Out of 120 anesthesiologists, 24 (20%) had the habit of using sunscreen

and 96 (80%) were those who did not use sunscreen. Out of 24 (20%) anesthesiologists using sunscreen, only two (8.3%) had sufficient level, which was statistically nonsignificant ( $P = 0.707$ ). Out of 120 anesthesiologists, 106 (88.3%) were not taking vitamin D supplements and only 14 (11.7%) used to take vitamin D supplements. Four anesthesiologists were found vitamin D deficient who were taking vitamin D supplements as compared to 97 anesthesiologists not taking vitamin D supplements and were having vitamin D deficiency. This association was statistically significant ( $P = <0.001$ ).

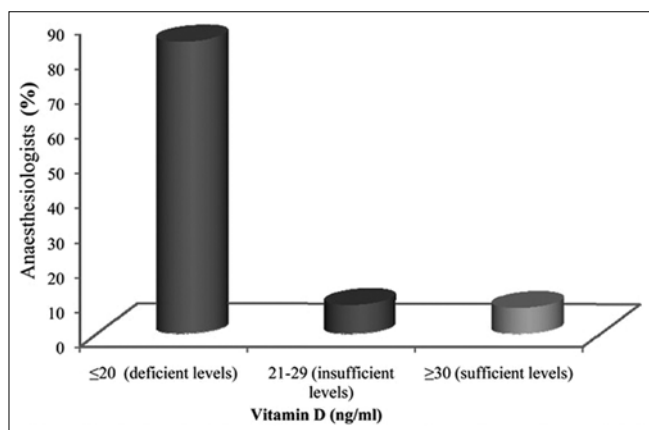
The serum calcium levels were normal in anesthesiologist irrespective of vitamin D levels. Two anesthesiologists were receiving omega 3 fatty acids, and three anesthesiologists had episodes of diarrhea in the last two weeks; we were not able to find any association with vitamin D status. There was no anesthesiologist diagnosed with Crohn’s disease, ulcerative colitis or coeliac sprue. None of the anesthesiologist reported any symptoms regarding vitamin D deficiency.

## Discussion

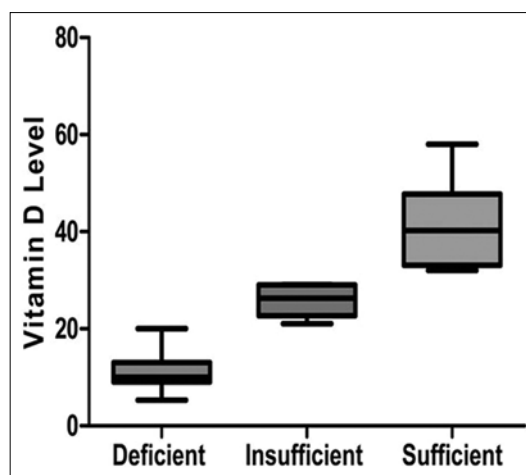
**Table 1: Demographic characteristics of 120 anesthesiologists**

Demographic characteristics	Anesthesiologist (n=120)
Age (yrs)	30.15 $\pm$ 6.09 (25-61)
Height (cm)	165.34 $\pm$ 9.87 (135-192)
Weight (kg)	66.76 $\pm$ 12.02 (42-110)
BMI (kg m <sup>2</sup> )	24.34 $\pm$ 3.42 (15.8-39.0)

Data are represented as mean  $\pm$  standard deviation (range). BMI (body mass index), one sample Kolmogorov-Smirnov test



**Figure 1:** Bar diagram showing the percentage of levels of vitamin D status of 120 anesthesiologists. Deficient vitamin D level: 25(OH) D levels  $\leq 20 \text{ ng.ml}^{-1}$ . Insufficient vitamin D level: 25(OH) D levels 21-30  $\text{ng.ml}^{-1}$ . Sufficient vitamin D level: 25(OH)D levels  $\geq 30 \text{ ng.ml}^{-1}$

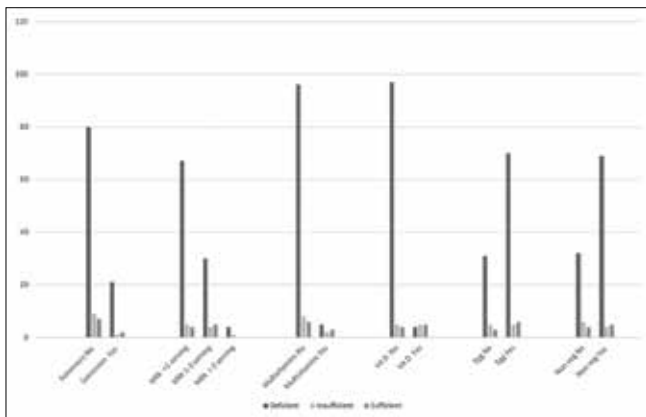


**Figure 2:** Box and whisker plot showing vitamin D levels ( $\text{ng ml}^{-1}$ ) of anaesthesiologists working in a tertiary care hospital. Deficient vitamin D level: 25(OH) D levels  $\leq 20 \text{ ng.ml}^{-1}$ . Insufficient vitamin D level: 25(OH) D levels 21-30  $\text{ng.ml}^{-1}$ . Sufficient vitamin D level: 25(OH)D levels  $\geq 30 \text{ ng.ml}^{-1}$

**Table 2: Comparison of professional work duration of 120 anesthesiologists and vitamin D status**

Professional work duration	Deficient vitamin D level	Insufficient vitamin D level	Sufficient vitamin D level	P
	(n=101)	(n=10)	(n=9)	
Period of working in anesthesia (months)				
≤12 months (n=28)	26 (92.9) (25.7)	2 (7.1) (20.0)	0 (0) (0)	0.005*
>12-60 months (n=73)	62 (84.9) (61.4)	6 (8.2) (60.0)	5 (6.8) (55.6)	
>60-120 months (n=9)	8 (88.9) (7.9)	1 (11.1) (10.0)	0 (0) (0)	
>120 months (n=10)	5 (50.0) (5.0)	1 (10.0) (10.0)	4 (40.0) (44.4)	
Sun exposure				
<5 minutes day-1 (n=67)	57 (85.1) (56.4)	6 (9.0) (60.0)	4 (6.0) (44.4)	0.688
5-15 minutes day-1 (n=26)	20 (76.9) (19.8)	2 (7.7) (20.0)	4 (15.4) (44.4)	
15-30 minutes day-1 (n=20)	18 (90.0) (17.8)	1 (5.0) (10.0)	1 (5.0) (11.1)	
>30 minutes day-1 (n=7)	6 (85.7) (5.9)	1 (14.3) (10.0)	0 (0) (0)	
Working hours day <sup>-1</sup> mean±SD (range) <sup>a</sup>	10.82±1.50 (8-15)	10.60±1.58 (8-12)	9.44±1.88 (8-14)	0.030*

Data are represented as n (%). P≤0.05 as statistically significant; Chi-square test. <sup>a</sup>Mann-Whitney test



**Figure 3:** Bar diagram showing lifestyle and dietary behavior of 120 anesthesiologists and vitamin D status. Deficient vitamin D level: 25(OH) D levels ≤20 ng.ml<sup>-1</sup>. Insufficient vitamin D level: 25(OH) D levels 21-30 ng.ml<sup>-1</sup>. Sufficient vitamin D level: 25(OH) D levels ≥30 ng.ml<sup>-1</sup>

The main findings of this observational study were that vitamin D deficiency was as high as 84% in apparently healthy anesthesiologists. The novelty of the present observational study was that 120 anesthesiologists of the same tropical region (enough sun exposure throughout the year) were analyzed. We enrolled participants who had worked for at least 6 months in anesthesia to maintain uniformity in the study population. In previously published studies, a smaller sample of anesthesiologist and mostly from colder regions of the world were studied.<sup>[12,13]</sup>

Vitamin D levels performed in doctors residing in the sunny climate region reported no significant risk of vitamin D

deficiency.<sup>[14]</sup> However, there is a high prevalence (70–100%) of vitamin D deficiency in a tropical country, even in the general healthy population.<sup>[5]</sup> Another study from the tropical region revealed a very high prevalence of vitamin D deficiency in healthcare professionals.<sup>[15]</sup> Arya *et al.* demonstrated a high prevalence (78.3%) of vitamin D deficiency among healthy hospital staff workers.<sup>[15]</sup> We conducted our study in the summer season, which is a time of discomfort due to extreme temperature; hence increased time is spent indoors and skin covered. This could probably be a factor resulting in vitamin D deficiency.

Studies from different parts of the world have shown a high prevalence of vitamin D deficiency to a varying degree in medical residents.<sup>[16,17]</sup> Davila *et al.* in their study found that limited sun exposure during the period of high intensity, increased body mass index, and limited area of the body exposed to the sun were positively correlated with lower 25(OH) D levels but with the weak association.<sup>[16]</sup> The average number of hours for anesthesiologists (residents and consultants) was not significantly associated with any change in vitamin D levels in this study.

However, with increased work experience in years, consultants had a lower prevalence of vitamin D deficiency. This was probably as with increasing age and experience, anesthesiologists were more aware of the problem, hence most of them were taking multivitamin and vitamin D supplementation. The younger age group was probably at higher risk for vitamin D deficiency because of aggressive sun protection, night duty hours, and day time sleepiness.<sup>[18]</sup>

Haney *et al.* reported that sun exposure, multivitamin, and dietary vitamin D intake were important predictors of vitamin D levels.<sup>[19]</sup> In this study, most of the anesthesiologists had less than 5 minutes of sun exposure per day as most of the anesthesiologists remained inside the operation theater during day time. However, other lifestyle-related questions like clothing, covering of bare skin were not recorded. This could be important as in South Asian countries, it is common to cover most of the body parts, leaving only the arms and face exposed. Dietary vitamin D intake is also an important predictor of vitamin D levels. In our study, dietary vitamin D (milk intake, egg intake, non-vegetarian diet, omega 3 fatty acid intake) did not find a significant association with vitamin D status. In contrast, Haney *et al.* reported a direct association between dietary intake and vitamin D levels.<sup>[19]</sup> This study was an observational study based on recall bias and characteristics of the questionnaire may have had an impact on the results. A typical diet in this part of the country lacks a rich source of vitamin D like cod liver oil. Thus, sunlight practically remains the only source of vitamin D.

Skarphdinsdottir *et al.* reported that vitamin D levels were within the normal range in anesthesiologists who were taking supplements (cholecalciferol and multivitamins) irrespective of the total number of years working in anesthesia.<sup>[13]</sup>

BMI in all groups was comparable and no statistically significant difference was found in this study. A similar result was found in the study by Mendoza *et al.*, which showed no significant association between vitamin D status and BMI.<sup>[17]</sup>

Statistically, non-significant association was found between serum calcium concentration and vitamin D status. Our results are in agreement with that of Haney *et al.* which shows a nonsignificant change in serum calcium in response to lower vitamin D levels, suggesting a physiological response to lower vitamin D levels in the form of a secondary increase in parathyroid hormone resulting in normal serum calcium.<sup>[19]</sup>

There is no direct relationship between serum 25(OH) D levels and low bone mineral density (BMD) of the hip and lumbar spine. However, a negative correlation between parathyroid hormone (PTH) and serum 25(OH) D concentrations  $<30 \text{ ng.ml}^{-1}$  was observed.<sup>[20]</sup> A study in healthy postmenopausal women also showed no correlation between serum 25(OH) D levels and BMD at the hip and lumbar spine. Although osteoporosis was seen in 24%, osteopenia in 55% at hip level, and 23% and 59%, respectively at the lumbar spine.<sup>[21]</sup> Due to the high cost of BMD and inconsistent results of BMD and vitamin D association, BMD measurement was not included in our study.

This study has several limitations. First, we did not have a control group as the aim was to find the levels of vitamin D in anesthesiologists and compare them with published literature. Second, serum phosphorus levels, serum PTH levels and other biomarkers like alkaline phosphatase (ALP) were not evaluated in this study. If nearly 100% of Indians have insufficient vitamin D levels, then we should look at what should be the right levels for Indians. Hence, further multicentric trials on a larger population of anesthesiologist need to be planned in future for determining vitamin D levels for India.

We conclude that the prevalence of vitamin D deficiency/insufficiency was high among anesthesiologists, however, levels were optimal in professionals, taking vitamin D supplements.

### Financial support and sponsorship

Government Medical College and Hospital, Chandigarh, India

### Conflicts of interest

There are no conflicts of interest.

### References

1. Webb AR. Who, what, where and when-influences on cutaneous vitamin D synthesis. *Prog Biophys Mol Biol* 2006;92:17-25.
2. Wang TJ, Pencina MJ, Booth SL, Jacques PF, Ingelsson E, Lanier K, *et al.* Vitamin D deficiency and risk of cardiovascular disease. *Circulation* 2008;117:503-11.
3. Carrelli AL, Walker MD, Lowe H, McMahon DJ, Rundek T, Sacco RL, *et al.* Vitamin D deficiency is associated with subclinical carotid atherosclerosis: The Northern Manhattan study. *Stroke* 2011;42:2240-5.
4. Mohr SB, Garland CF, Gorham ED, Garland FC. The association between ultraviolet B irradiance, vitamin D status and incidence rates of type 1 diabetes in 51 regions worldwide. *Diabetologia* 2008;51:1391-8.
5. Ritu G, Gupta A. Vitamin D deficiency in India: Prevalence, causalities and interventions. *Nutrients* 2014;6:729-75.
6. Palacios C, Gonzalez L. Is vitamin D deficiency a major global public health problem? *J Steroid Biochem Mol Biol* 2014;144:138-45.
7. Sowah D, Fan X, Dennett L, Hagtvedt R, Straube S. Vitamin D levels and deficiency with different occupations: A systematic review. *BMC Public Health* 2017;17:519.
8. Harinarayan CV, Holick MF, Prasad UV, Vani PS, Himabindu G. Vitamin D status and sun exposure in India. *Dermatoendocrinol* 2013;5:130-41.
9. Bolek-Berquist J, Elliot ME, Gangnon RE, Gemar D, Engelke J, Lawrence SJ, *et al.* Use of a questionnaire to assess vitamin D status in young adults. *Public Health Nutr* 2009;12:236-43.
10. Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP, *et al.* Evaluation, treatment, and prevention of vitamin D deficiency: An endocrine society clinical practice guideline. *J Clin Endocrinol Metab* 2011;96:1911-30.
11. Ramakrishnan S, Bhansali A, Bhadada SK, Sharma R, Walia R, Ravikiran M, *et al.* Vitamin D status and its seasonal variability in healthy young adults in an Asian Indian urban population. *Endocr Pract* 2011;17:185-91.
12. Aguilera G, Barberan M, Vargas J, Maldonado F, Brunet L,



- Caamano E, *et al.* 25-Hydroxyvitamin D deficiency among anaesthesiologists and anaesthesiology residents in Chile. *Br J Anaesth* 2017;118:951-2.
13. Skarphedinsdottir SJ, Sigurdsson MI, Coursin DB, Head DE, Springman SR, Wang S, *et al.* Vitamin D deficiency in anaesthesia department caregivers at the end of winter. *Acta Anaesthesiol Scand* 2014;58:802-6.
  14. Moran-Lev H, Mandel D, Weisman Y, Ovental A, Lubetzky R. Vitamin D status among Israeli medical residents. *Isr Med Assoc J* 2017;19:341-4.
  15. Arya V, Bhambri R, Godbole MM, Mithal A. Vitamin D status and its relationship with bone mineral density in healthy Asian Indians. *Osteoporos Int* 2004;15:56-61.
  16. Davila LH, Rivera NR, Valentin ML, Haddock L, Martinez RR, Bossolo AG, *et al.* Prevalence of vitamin D insufficiency and deficiency among Young Physicians at University District Hospital in San Juan, Puerto Rico. *P R Health Sci J* 2015;34:83-8.
  17. Mendoza V, Villanueva MT, Vargas G, Gonzalez B, Halabe J, Simon J, *et al.* Vitamin D deficiency among medical residents and its relationship with metabolic indices. *Endocr Prac* 2013;19:59-63.
  18. Khetarpal R, Chatrath V, Kaur J, Verma A. Occupational stress in anesthesiologists and coping strategies: A review. *Int J Sci Stud* 2015;3:188-92.
  19. Haney EM, Stadler D, Blizoiotes MM. Vitamin D insufficiency in internal medicine residents. *Calcif Tissue Int* 2005;76:11-6.
  20. Kota S, Jammula S, Kota S, Meher L, Modi K. Correlation of vitamin D, bone mineral density and parathyroid hormone levels in adults with low bone density. *Indian J Orthop* 2013;47:402-7.
  21. Kamineni V, Latha AP, Ramathulasi K. Association between serum 25-hydroxyvitamin D levels and bone mineral density in normal postmenopausal women. *J Midlife Health* 2016;7:163-8.