ORIGINAL ARTICLE

Assessment of prevalence of hypovitaminosis D in multiethnic population of the United Arab Emirates

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ABSTRACT

United Arab Emirates (UAE) has a high prevalence of hypovitaminosis D. Not much data are available regarding the prevalence of Vitamin D deficiency among multiethnic UAE adult population. (1) To determine the prevalence of hypovitaminosis D in multiethnic UAE population (2) To compare the Vitamin D status in Arab and non-Arab population (3) To identify the demographic variables associated with hypovitaminosis D. It was a retrospective study conducted at a secondary care hospital. Electronic case records of all the subjects who had checked their Vitamin D levels during the time period of May 2010–October 2012 were considered for the study. Vitamin D severe deficiency, deficiency, insufficiency, and sufficiency were defined as serum 25-hydroxy Vitamin D (25(OH)D) levels <10 ng/mL, 10–20 ng/mL, 21–30 ng/mL, and >30 ng/mL, respectively. A total 425 subjects were included for the data analysis. Vitamin D deficiency was diagnosed in 208 (48.9%) subjects followed by severe Vitamin D deficiency and insufficiency in 141 (33.2%) and 63 (14.8%) subjects, respectively. The overall prevalence of hypovitaminosis D was 96.9%. Negative association ($r = -0.196$, $P < 0.01$) was observed between body mass index (BMI) and 25(OH)D levels. Ethnicity was not ($P = 0.103$) a predictor of 25(OH)D levels. Majority of our study subjects had Vitamin D deficiency. There was no substantial difference in 25(OH)D levels of different ethnic groups. Female gender, age, and BMI were the predictors 25(OH)D levels.

Key words: Hypovitaminosis D, Middle-East, prevalence, United Arab Emirates, Vitamin D deficiency

INTRODUCTION

Hypovitaminosis D is considered to be the most common medical condition of rising prevalence across worldwide.[1] Around one billion people in the worldwide are known to be affected by hypovitaminosis D.[2] The prevalence rate of hypovitaminosis D varies among different countries and among different ethnic groups of the same country.[3] United Arab Emirates (UAE) has a high prevalence of hypovitaminosis D, in spite of abundant sunlight.[4]

Hypovitaminosis D is a major risk factor for the development of metabolic bone disease.[5] Several studies have reported the association among hypovitaminosis D and cardiovascular diseases, multiple sclerosis, metabolic syndrome, and diabetes mellitus.[3]

Few published studies are available on the prevalence of hypovitaminosis D in UAE multiethnic population and

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associated demographic variables. Hence, data collected from this preliminary study could be useful for further research in this area. With this background, the objectives of the present study were to determine the prevalence of hypovitaminosis D in multiethnic UAE population. The study also aimed at comparing the Vitamin D status in Arab and non-Arab population and to identify the demographic variables associated with hypovitaminosis D.

MATERIALS AND METHODS

This was a retrospective study conducted at a secondary care hospital of UAE. The study was approved by the Research and Ethics Committee. We reviewed the electronic case records of 425 subjects, who had checked their Vitamin D levels during the time period of May 2010–October 2012. The data of subjects of both sex aged >18 years and who were previously undiagnosed or diagnosed with Vitamin D deficiency were included. We excluded the data of those subjects whose electronic case records were incomplete, Vitamin D measurement results were contradicting and if subjects were nonresidents of UAE.

Operational definitions

Based on our laboratory reference values, Vitamin D severe deficiency, deficiency, insufficiency, and sufficiency were defined as a 25-hydroxy Vitamin D (25(OH)D) levels <10 ng/mL, 10–20 ng/mL, 21–30 ng/mL, and >30 ng/mL, respectively. This operational definition was based on the international consensus.[6] The prevalence of hypovitaminosis D was calculated based on the percentage of the total number of cases who were having hypovitaminosis D (<30 ng/mL) by the total number of cases in whom 25(OH)D levels was measured.

Statistical analysis

The data were analyzed using SPSS 20, IBM, Armonk, NY, United States of America. Continuous variables were compared using Student's *t*-test or one-way ANOVA. Pearson Chi-square test was used to assess the significant relationship between categorical variables and 25(OH)D levels. Pearson correlation test was applied to examine the association between continuous demographic variables and Vitamin D levels. Multiple regression analysis was done to examine the effect of variables on Vitamin D levels.

RESULTS

A total of 425 subjects satisfying inclusion criteria were included for the data analysis. Good number of study population was males 243 (57.2%). Majority of our study subjects were Indians 228 (53.6%) [Table 1].

25-hydroxy Vitamin D levels of study subjects

The mean 25(OH)D levels of the study subjects were 14.0 ± 8.1 ng/mL. Vitamin D deficiency, severe deficiency, and insufficiency were diagnosed in 208 (48.9%), 141 (33.2%), and 63 (14.8%) subjects, respectively. The overall prevalence of hypovitaminosis D (combination of severe deficiency, deficient, or insufficiency) was found to be 96.9% [Table 2].

Symptoms of hypovitaminosis D

Majority 287 (67.5%) were having generalized pain and weakness. It is interesting to note that 101 (23.8%) subjects were asymptomatic [Table 2].

Presence of comorbidities

Hypertension existed as the most common comorbidity affecting 249 (58.6%) subjects, followed by dyslipidemia in 246 (57.9%) subjects [Figure 1].

Gender and 25-hydroxy Vitamin D levels

The 25(OH)D levels of males (15.3 ± 8.3 ng/mL) were significantly higher ($P < 0.05$) than females (12.3 ± 7.2 ng/mL) [Table 1]. There was a significant relationship between the gender and Vitamin D levels (χ^2 = 13.1, df = 3, P = 0.004) [Table 2].

Ethnicity and 25-hydroxy Vitamin D levels

There was no significant difference (P = 0.059) in the mean 25(OH)D levels of subjects of different ethnic

Table 1: Demographic variables and mean±SD 25-hydroxy Vitamin D levels

Variable	*n* (%)	Mean±SD levels of 25(OH)D (ng/ml)	df	*F*	Significance (two-tailed)
Gender[a]					
Male	243 (57.2)	15.3±8.5	421		<0.01*
Female	182 (42.8)	12.3±7.2			
Ethnicity[b]					
Indian	228 (53.6)	14.3±7.7	6	2.03	0.059
Pakishtani	40 (9.4)	14.1±7.4			
Bangladeshi	01 (0.2)	16.5±00			
Sri Lankan	09 (2.1)	13.8±4.4			
Arab	130 (30.6)	12.7±9.0			
Philippines	102.4)	18.5±3.9			
Caucasians	07 (1.6)	21.2±10.1			
Age (in years)[b]					
10-20	07 (1.64)	15.5±10.9	5	2.66	0.022*
21-30	30 (7.05)	10.8±5.1			
31-40	102 (24)	12.8±7.3			
41-50	146 (34.3)	±8.5			
51-60	129 (30.3)	±8.3			
>60	11 (2.5)	13.9±7.8			
BMI (kg/m^2)[a]					
<25	165 (38.9)	16.5±8.6	351		0.001*
≥25	260 (61.1)	13.2±8.0			

[a]By Student's *t*-test; [b]By ANOVA. *P<0.05 is considered as statistically significant. BMI: Body mass index, SD: Standard deviation, 25(OH)D: 25-hydroxy Vitamin D

Table 2: Association among demographic variables, symptoms of hypovitaminosis D and 25-hydroxy Vitamin D levels

Variable	*n* (%)	Severe deficiency <10 (ng/ml)	Deficiency 10-20 (ng/ml)	Insufficiency 21-30 (ng/ml)	Sufficiency >30 (ng/ml)	*P*
Gender						
Male	243 (57.2)	68 (48.2)	119 (57.2)	47 (74.6)	09 (69.2)	0.004*
Female	182 (42.8)	73 (51.8)	89 (42.8)	16 (25.4)	04 (30.8)	
Ethnicity						
Indian	228 (53.6)	72 (51.1)	113 (54.3)	38 (60.3)	05 (38.5)	0.004*
Pakishtani	40 (9.4)	13 (9.2)	20 (9.6)	07 (11.1)	00 (0)	
Bangladeshi	01 (0.2)	00 (0)	01 (0.5)	00 (0)	00 (0)	
Sri Lankan	09 (2.1)	01 (0.7)	07 (3.4)	01 (1.6)	00 (0)	
Arab	130 (30.6)	55 (39.0)	56 (26.9)	13 (20.6)	06 (46.2)	
Philippines	10 (2.4)	00 (0)	07 (3.4)	03 (4.8)	00 (0)	
Caucasians	07 (1.6)	00 (0)	04 (1.9)	01 (1.6)	02 (15.4)	
Age (in years)						
10-20	07 (1.6)	02 (14.3)	04 (1.9)	00 (0)	01 (7.7)	0.080
21-30	30 (7.0)	12 (8.6)	17 (8.2)	01 (1.6)	00 (0)	
31-40	102 (24.0)	38 (26.9)	52 (25.0)	10 (15.9)	02 (15.3)	
41-50	146 (34.3)	53 (37.6)	68 (32.7)	19 (30.2)	06 (46.2)	
51-60	129 (30.3)	32 (22.7)	62 (29.9)	31 (49.2)	04 (30.8)	
>60	11 (2.5)	04 (2.9)	05 (2.5)	02 (3.1)	00 (0)	
Symptoms of hypovitaminosis D						
Backache						
Yes	154 (36.2)	61 (43.3)	80 (38.5)	10 (15.9)	03 (23.1)	0.001*
No	271 (63.8)	80 (56.7)	128 (61.5)	53 (84.1)	10 (76.9)	
Muscle cramps						
Yes	82 (19.3)	30 (21.3)	39 (18.8)	8 (12.7)	05 (38.5)	0.156
No	343 (80.7)	111 (78.7)	169 (81.3)	55 (87.3)	08 (61.5)	
Muscle pain						
Yes	247 (58.1)	92 (65.2)	126 (60.6)	24 (38.1)	05 (38.5)	0.001*
No	178 (41.9)	49 (34.8)	82 (39.4)	39 (61.9)	08 (61.5)	
Muscle weakness						
Yes	210 (49.8)	83 (59.3)	100 (48.5)	24 (38.1)	03 (23.1)	0.006*
No	212 (50.2)	57 (40.7)	106 (51.5)	39 (61.9)	10 (76.9)	
Generalized aches and weakness						
Yes	287 (67.7)	109 (77.3)	145 (69.7)	30 (48.4)	03 (23.1)	<0.01*
No	137 (32.3)	32 (22.7)	63 (30.3)	32 (51.6)	10 (76.9)	
Proximal muscle weakness						
Yes	11 (2.6)	05 (3.5)	05 (2.4)	00 (0)	01 (7.7)	0.313
No	414 (97.4)	136 (96.5)	203 (97.6)	63 (100)	12 (92.3)	
Asymptomatic						
Yes	101 (23.8)	24 (17.0)	51 (24.5)	23 (36.5)	03 (23.1)	0.026*
No	324 (76.2)	117 (83.0)	157 (75.5)	40 (63.5)	10 (76.9)	

*$P<0.05$ is statistically significant by Chi-square test

background [Table 1]. However, we observed a significant relationship between ethnicity and 25(OH)D levels ($\chi^2 = 37.60$, df = 18, $P = 0.004$) [Table 2].

Age and 25-hydroxy Vitamin D levels

The mean 25(OH)D levels of subjects belonging to age group of 21–30 years was lower (10.8 ± 5.1ng/mL) compared to other age groups [Table 1]. There was no statistically significant relationship ($P > 0.05$) between 25(OH)D levels and age ($\chi^2 = 23.2$, df = 15, $P = 0.08$) [Table 2].

ANOVA showed a significant difference ($P = 0.022$) in the 25(OH)D levels of subjects belonging to different age groups. However, *post hoc* analysis by Bonferroni showed only significant difference ($P = 0.041$) in subjects belonging to 21–30 years (10.8 ± 5.1 ng/mL) and 50–60 years (15.8 ± 8.3 ng/mL) [Table 1].

Body mass index and 25-hydroxy Vitamin D levels

There was a significant difference ($P = 0.001$) in the mean 25(OH)D levels of subjects with body mass index (BMI) <25 kg/m^2 (16.5 ± 8.6 ng/mL) and > 25 kg/m^2 (13.2 ± 8.0 ng/mL) [Table 1].

Symptoms of hypovitaminosis D and 25-hydroxy Vitamin D levels

A significant association ($P < 0.05$) was documented among 25(OH)D levels and back ache ($\chi^2 = 15.73$, df = 3, $P = 0.01$), muscle pain ($\chi^2 = 15.90$, df = 3, $P = 0.001$), muscle weakness ($\chi^2 = 12.33$, df = 3, $P = 0.006$), generalized aches/weakness ($\chi^2 = 28.74$, df = 3, $P < 0.01$), and in subjects without any symptoms ($\chi^2 = 9.25$, df = 3, $P = 0.026$) [Table 2].

Association among age, height, weight, body mass index, and 25-hydroxy Vitamin D levels

A significant ($r = 0.130$, $P = 0.008$) positive association was detected between the age and 25(OH)D levels of the subjects. Whereas significant ($r = -0.196$, $P < 0.01$) negative association was also noticed between BMI and Vitamin D levels [Table 3].

Predictors of 25-hydroxy Vitamin D levels

BMI ($R^2 = 0.077$, f (4, 351) =7.33, Beta = −0.202, $P < 0.01$) and gender ($R^2 = 0.077$, f (4, 351) =7.33, Beta = −0.179, $P = 0.027$) were significant negative predictors of 25(OH)D levels. Whereas, age was a significant positive predictor (Beta = 0.117, $P = 0.031$) and ethnicity had no influence on 25(OH)D levels [Table 4].

DISCUSSION

The overall prevalence of hypovitaminosis D documented in our study is in agreement with the findings of another study, which reported 90.5% prevalence among UAE women.[7] The prevalence hypovitaminosis D in different Middle-East and Asian countries is found to be 35–68.8%.[8,9] Our findings were consistent with overall prevalence data of hypovitaminosis D in India (50–90%) and Pakistan (85–98%).[10,11] A good number of our study populations were Indian and Pakistani residents.

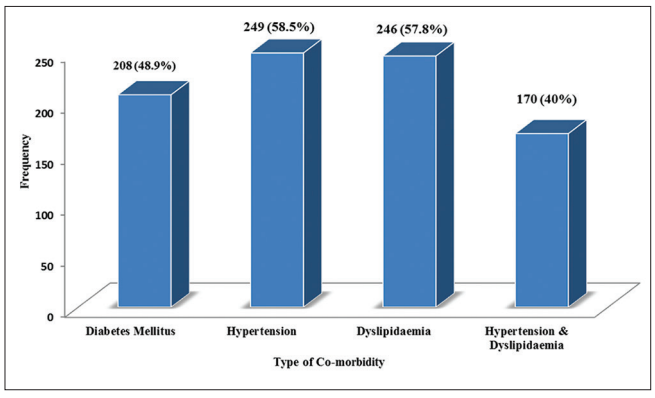

Figure 1: Associated comorbidities present in study population

The prevalence of hypovitaminosis D documented in our study was found to be higher than reports from different Middle-East countries.[8,9] This could be due to dissimilarity in age, gender, race, dressing pattern (veil vs. nonveil), cultural practice, geographic region, food habit, skin tone, exposure to sun, sunscreen usage, type of the study sample (healthy population vs. diseased), sample size, and difference in the 25(OH)D reference ranges or cut-off values.[9,12]

Mean 25(OH)D levels were lower ($P < 0.05$) in female subjects. Lower levels of Vitamin D are also reported in other studies.[13] In contrast, a study reported significantly ($P < 0.001$) lower mean 25(OH)D concentrations in morbidly obese males. The lower 25(OH)D levels among women may be because of lack of exposure to sunlight, less time spent outdoor, and dressing pattern due to sociocultural or religious reasons.[14]

Generalized body aches/weakness and muscle pain were the most common symptoms reported by the patients. Similar observations have been reported in other studies.[15] A multiethnic Norwegian study identified nonspecific musculoskeletal pain, headache, or fatigue as the common symptoms.[16] Studies have reported that 26–100% patients with a presenting symptom of musculoskeletal pain are likely to have hypovitaminosis D.[17]

In accordance with our findings, other studies have also reported hypertension as the most common risk factor followed by dyslipidemia and diabetes.[18] Another study reported hyperglycemia and dyslipidemia as the most prevalent comorbidities followed by central obesity and hypertension.[19]

Table 3: Correlation among continuous demographic, clinical variables, and 25-hydroxy Vitamin D levels

Variables	Pearson correlation (*r*)	*P*
Age	0.130**	0.008
Height (in cm)	0.092	0.070
Weight (in kg)	−0.114*	0.020*
BMI	−0.196**	<0.01**

*Correlation is significant at the 0.05 level (two-tailed), **Correlation is significant at the 0.01 level (two-tailed). BMI: Body mass index

Table 4: Multivariate regression analysis of the variables and 25-hydroxy Vitamin D levels

Variables	*B*	Beta	*t*	*P*
Gender	−0.197	−0.124	−2.223	0.027*
Ethnicity	0.036	0.088	1.635	0.103
Age	0.009	0.117	2.170	0.031*
BMI	−0.031	−0.202	−3.789	<0.01*

*P<0.05 statistically significant. BMI: Body mass index

In line with our findings, other studies have also reported a higher prevalence of hypovitaminosis D in middle-aged subjects.[20] In contrast to our findings, other studies have reported predominance in diverse age groups.[13,21] This difference in the prevalence might be due to the fact that majority of our samples were in the age group 41–50 years.

Vitamin D deficiency occurs in all age groups ranging from children to elderly.[22] However, the cutaneous production of Vitamin D and ability to synthesize Vitamin D decreases with the age.[23] In spite of this, it is interesting to note that age was positively correlated with 25(OH)D levels in our study. This finding is in accordance with other studies from Middle-East Countries, which reported a positive correlation between age and Vitamin D levels.[24]

We noticed a higher 25(OH)D levels in the age group of 51–60 years. Our study population also consisted of previously diagnosed hypovitaminosis D subjects, who might have already received parenteral Vitamin D therapy. This could be the reason for higher 25(OH)D levels in this age group.[25] In contrast, studies have also documented an inverse association.[26] Whereas few studies have not documented any correlation between age and 25(OH)D levels.[27]

Our findings were in accordance with other studies, which reported significant decrease in 25(OH)D levels with increasing BMI.[28] However, a meta-analysis study showed a significant inverse weak association between Vitamin D levels and BMI in adult men.[29] On the contrary, few studies found no association.[30] The postulated reasons for low levels of 25(OH)D levels in obese patients are multifactorial such as decreased bioavailability of Vitamin D, excessive storage of Vitamin D in adipose tissue, elevated parathyroid hormone levels, decreased mobility, and breakdown of vitamin due to increased oxidative reactions in adipose tissue.[31]

No significant difference ($P > 0.05$) in the Vitamin D levels of different ethnic groups was observed in our study. In contrast, few studies conducted in other parts of the world have documented difference among different ethnic groups or races.[32] However, few studies did not document any such difference.[33] The proposed reasons for difference in the findings could be due to skin color, sun exposure, latitude, or region in which the subjects are living have been stated in the literature.[34]

The main limitations of our study were that the results were based on the single measurement of 25(OH)D levels and was limited to subjects visiting single center, which may not be the complete representation of the different ethnic groups living in UAE. Since ours was a retrospective study, we could not obtain information on skin exposure time, dressing pattern, and food habit details. Hence, we could not present these data in our study.

CONCLUSION

Higher prevalence of hypovitaminosis was observed in males when compared to females. There was no significant difference in the Vitamin D levels of different ethnic groups. Hypertension was the most commonly observed comorbidity in the study subjects. A negative association was documented between BMI of the subjects and 25(OH)D levels. BMI was the negative predictor of 25(OH)D levels.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Baz-Hecht M, Goldfine AB. The impact of Vitamin D deficiency on diabetes and cardiovascular risk. Curr Opin Endocrinol Diabetes Obes 2010;17:113-9.
2. Nair R, Maseeh A. Vitamin D: The "sunshine" vitamin. J Pharmacol Pharmacother 2012;3:118-26.
3. Mithal A, Wahl DA, Bonjour JP, Burckhardt P, Dawson-Hughes B, Eisman JA, *et al.* Global Vitamin D status and determinants of hypovitaminosis D. Osteoporos Int 2009;20:1807-20.
4. Dawodu A, Kochiyil J, Altaye N. Pilot study of sunlight exposure and Vitamin D status in Arab women of childbearing age. East Mediterr Health J 2011;17:570-4.
5. Turner AG, Anderson PH, Morris HA. Vitamin D and bone health. Scand J Clin Lab Invest Suppl 2012;243:65-72.
6. Flood-Nichols SK, Tinnemore D, Huang RR, Napolitano PG, Ippolito DL. Vitamin D deficiency in early pregnancy. PLoS One 2015;10:e0123763.
7. Al Attia HM, Ibrahim MA. The high prevalence of Vitamin D inadequacy and dress style of women in the sunny UAE. Arch Osteoporos 2012;7:307-10.
8. Fuleihan GE, Deeb M. Hypovitaminosis D in a sunny country. N Engl J Med 1999;340:1840-1.
9. Rahnavard Z, Eybpoosh S, Homami MR, Meybodi HA, Azemati B, Heshmat R, *et al.* Vitamin D deficiency in healthy male population: Results of the Iranian multi- center osteoporosis study. Iran J Public Health 2010;39:45-52.
10. Harinarayan CV, Joshi SR. Vitamin D status in India – Its implications and remedial measures. J Assoc Physicians India 2009;57:40-8.
11. Sheikh A, Saeed Z, Jafri SA, Yazdani I, Hussain SA. Vitamin D

levels in asymptomatic adults – A population survey in Karachi, Pakistan. PLoS One 2012;7:e33452.
12. Holick MF. Vitamin D deficiency. N Engl J Med 2007;357:266-81.
13. Hovsepian S, Amini M, Aminorroaya A, Amini P, Iraj B. Prevalence of Vitamin D deficiency among adult population of Isfahan City, Iran. J Health Popul Nutr 2011;29:149-55.
14. Batieha A, Khader Y, Jaddou H, Hyassat D, Batieha Z, Khateeb M, *et al*. Vitamin D status in Jordan: Dress style and gender discrepancies. Ann Nutr Metab 2011;58:10-8.
15. Haque IU, Salam TU, Hussain M, Iqbal W, Zafar S, Tayyab GU, *et al*. Assessment of the Vitamin D levels in the patients presenting with different medical conditions and its correlation with symptomatology. Annals 2009;15:60-3.
16. Knutsen KV, Brekke M, Gjelstad S, Lagerløv P. Vitamin D status in patients with musculoskeletal pain, fatigue and headache: A cross-sectional descriptive study in a multi-ethnic general practice in Norway. Scand J Prim Health Care 2010;28:166-71.
17. Prakash S, Kumar M, Belani P, Susvirkar A, Ahuja S. Interrelationships between chronic tension-type headache, musculoskeletal pain, and Vitamin D deficiency: Is osteomalacia responsible for both headache and musculoskeletal pain? Ann Indian Acad Neurol 2013;16:650-8.
18. Chaudhuri JR, Mridula KR, Anamika A, Boddu DB, Misra PK, Lingaiah A, *et al*. Deficiency of 25-hydroxyvitamin D and dyslipidemia in Indian subjects. J Lipids 2013;2013:623420.
19. Durga Prasad K, Havilah P, Vinodh P. A study of Vitamin D and metabolic syndrome in urban population. Int J Biol Med Res 2012;3:1731-4.
20. Kauppinen-Mäkelin R, Tähtelä R, Löyttyniemi E, Kärkkäinen J, Välimäki MJ. A high prevalence of hypovitaminosis D in Finnish medical in- and outpatients. J Intern Med 2001;249:559-63.
21. Al-Turki HA, Sadat Ali M, Al-Elq AH, Al-Mulhim FA, Al-Ali AK. 25-Hydroxy Vitamin D levels among healthy Saudi Arabian Women. Saudi Med J 2008;29:1765-8.
22. Palacios C, Gonzalez L. Is Vitamin D deficiency a major global public health problem? J Steroid Biochem Mol Biol 2014;144(Pt A):138-45.
23. MacLaughlin J, Holick MF. Aging decreases the capacity of human skin to produce Vitamin D3. J Clin Invest 1985;76:1536-8.
24. Alsuwadia AO, Farag YM, Al Sayyari AA, Mousa DH, Alhejaili FF, Al-Harbi AS, *et al*. Prevalence of Vitamin D deficiency in Saudi adults. Saudi Med J 2013;34:814-8.
25. Tak YJ, Lee JG, Song SH, Kim YJ, Lee S, Jung DW, *et al*. The relationship between the level of serum 25-hydroxyvitamin D and renal function in patients without chronic kidney disease: A cross-sectional study. J Ren Nutr 2015;25:88-96.
26. Alvarez-Rodriguez L, Lopez-Hoyos M, Garcia-Unzueta M, Amado JA, Cacho PM, Martinez-Taboada VM. Age and low levels of circulating Vitamin D are associated with impaired innate immune function. J Leukoc Biol 2012;91:829-38.
27. Lardner E, Fitzgibbon M, Wilson S, Griffin D, Mulkerrin E. Hypovitaminosis D in a healthy female population, aged from 40 to 85 years, in the west of Ireland. Ir J Med Sci 2011;180:115-9.
28. Lagunova Z, Porojnicu AC, Lindberg F, Hexeberg S, Moan J. The dependency of Vitamin D status on body mass index, gender, age and season. Anticancer Res 2009;29:3713-20.
29. Saneei P, Salehi-Abargouei A, Esmaillzadeh A. Serum 25-hydroxy Vitamin D levels in relation to body mass index: A systematic review and meta-analysis. Obes Rev 2013;14:393-404.
30. Baradaran A, Behradmanesh S, Nasri H. Association of body mass index and serum Vitamin D level in healthy Iranian adolescents. Endokrynol Pol 2012;63:29-33.
31. Codoñer-Franch P, Tavárez-Alonso S, Simó-Jordá R, Laporta-Martín P, Carratalá-Calvo A, Alonso-Iglesias E. Vitamin D status is linked to biomarkers of oxidative stress, inflammation, and endothelial activation in obese children. J Pediatr 2012;161:848-54.
32. Bartley J. Prevalence of Vitamin D deficiency among patients attending a multidisciplinary tertiary pain clinic. N Z Med J 2008;121:57-62.
33. Bogh MK, Schmedes AV, Philipsen PA, Thieden E, Wulf HC. Vitamin D production after UVB exposure depends on baseline Vitamin D and total cholesterol but not on skin pigmentation. J Invest Dermatol 2010;130:546-53.
34. Correia A, Azevedo Mdo S, Gondim F, Bandeira F. Ethnic aspects of Vitamin D deficiency. Arq Bras Endocrinol Metabol 2014;58:540-4.