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Vitamin D Status in Adults: A Cross Sectional Study

Jamal Golbahar, PhD* Nida Al-Saffar, MSc** Diab Altayab Diab, BSc***
Sara Al-Othman, BSc**** Abdullah Darwish, MD*****

Background: High prevalence of hypovitaminosis D has been reported to be common in different regions of the Middle East.

Objective: The aim of this study is to examine vitamin D level in relation to age, sex, season, clothing and use of supplements among healthy adults.

Design: A cross-sectional study.

Setting: Blood Bank, Bahrain Defense Hospital.

Method: This study was performed from February 2011 to January 2012. Vitamin D level was assessed in 500 healthy Bahrainis (250 males and 250 females) aged 15-65 years with no history of major organ diseases or any other health problems. The prevalence of vitamin D deficiency and insufficiency was determined according to the ranges of 25-hyroxyvitamin D (25(OH)D) recommended by the Institute of Medicine, USA.

Result: The mean total serum of 25(OH)D was low (22.9± 10.1 nmol/L) and total serum of 25(OH)D concentrations in 49.4%, 37.0% and 13.6% of the participants were having <30.0 nmol/L (deficiency), between 30.0-50.0 nmol/L (insufficiency) and >50.0 nmol/L (optimal).

Vitamin D deficiency was significantly higher in females 169 (67.6%) than males 78 (31.2%), p<0.0001. The prevalence of vitamin D deficiency among younger age group, <30 years, 139 (53%) was significantly higher than older age group, >30 years, 108 (45.4%), p<0.001. Vitamin D deficiency was significantly higher during October to March 121 (69.2%) than April to September 41 (12.5%), p<0.0001. In this study only 68 (13.6%) had optimal level of vitamin D suggesting an alarming vitamin D deficiency in Bahrainis.

Conclusion: This is the first population-based study in Bahrain that indicates vitamin D deficiency. It is recommended that fortification of food with vitamin D on a national basis is necessary to overcome such low levels of vitamin D in Bahrainis.

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* Associate Professor
Department of Molecular Medicine and Diagnostic Services
** Graduate Students
*** Metabolic Laboratory Technologist
**** Molecular Specialist
Diagnostic Services

Al-Jawhara Centre for Genetic Diagnosis and Research
Arabian Gulf University Bahrain
***** Head of Department,
Department of Pathology and Laboratory
Bahrain Defense Force Hospital
Kingdom of Bahrain
Email: jamalgo@agu.edu.bh

Prevalence of hypovitaminosis D has been reported to be high in various regions around the Middle East. Despite ample sunshine throughout the year, studies suggested that one-third of individuals living in Sub-Saharan Africa and the Middle East have serum 25(OH) D level <25 nmol/L[1]. Old age, female, malnutrition, dark skin pigmentation, lack of sun exposure, conservative clothing and prolonged breast-feeding in women without vitamin D supplementation have been reported to be among the risk factors associated with hypovitaminosis D in developing countries including Middle East[1-4].

Vitamin D2 (ergocalciferol) and D3 (cholecalciferol) can be obtained from exogenous sources, but only vitamin D3 is synthesized in the skin from 7-dehydrocholesterol upon exposure to sunlight[5-6]. These vitamins are metabolized to 25(OH)D2 and 25(OH)D3 in the liver and subsequently are converted to the biologically active 1, 25-dihydroxyvitamin D in the kidneys. Indeed, most steps involved in the metabolism and actions of vitamin D2 and vitamin D3 are identical and consequently these two forms of vitamins have been regarded to have the same effect and potency for treatment of rickets[7]. Serum levels of 25(OH)D have proven to be the most precise marker of vitamin D status as it reflects cutaneous synthesis as well as total intakes of vitamin D in foods and supplements[8]. In addition, 25(OH)D has a relatively long circulating half-life of about 15 days[9]. Serum total of 25(OH)D comprise the sum of 25(OH)D2 and 25(OH) D3 as vitamin D2 is present in food. In addition, patients suffer from vitamin D deficiency would also be treated by both vitamin D2 and vitamin D3.

Therefore, it is recommended that serum level of 25(OH)D2 and 25(OH)D3 should be determined in order to assess vitamin D level and its clinical nutritional status. However, there is still a controversy whether 25(OH)D is a biomarker of exposure or a biomarker of effect[8].

Generally, it is reported that younger individuals have higher levels of vitamin D than older ones, and males have slightly higher levels of vitamin D than females[10-12].

In the past decade there has been conflicting reports regarding the cut-off values to define the optimal levels of vitamin D and also its insufficiency and deficiency in different populations. However, vitamin D levels in a given population may depend on the latitude, demography, clothing habits, skin pigmentation and diet[13-15]. A person is at risk of vitamin D deficiency with serum 25(OH)D concentrations of <30 nmol/L and inadequacy at levels ranging from 30-50 nmol/L; 50 nmol/L (optimal) is the serum 25(OH)D level that covers the needs of 97.5% of a population[8].

Vitamin D insufficiency and deficiency have been mostly associated with high latitude due to low exposure to ultraviolet radiation (UV) in those regions far from the equator. However, recent studies suggest that vitamin D deficiency and insufficiency are not only limited to sun-deprived areas but it is indeed more common in sunny region particularly in the Middle Eastern countries including; Turkey, Lebanon, Iran, Saudi Arabia, United Arab Emirates and Jordon due to cultural factors[16-21].

The aim of this study is to determine vitamin D level in relation to age, sex, season, clothing habits and use of supplements in healthy adults living in Bahrain.

METHOD

This study was performed from February 2011 to January 2012 on volunteers who attended the blood bank center in Bahrain Defense Force hospital. Six hundred twenty-three agreed to participate, 123 individuals were excluded, 72 were non-Bahrainis and 51 had history of liver, renal, gastrointestinal or endocrine disorders including hyper or hyperthyroidism, osteomalacia, vitamin deficiencies and on drugs therapy. Informed consent was taken from the participants.

Serum 25(OH)D3 and 25(OH)D2 concentrations were determined by ultra performance liquid chromatography tandem mass spectrometry (UPLC-MS/MS) using commercially available kits (Chromsystems Instruments & Chemicals GmbH, Germany). The intra-assay coefficient of variations (CVs) for 25(OH)D3 and 25(OH)D2 were 3.9% and 4.3%, respectively. The CVs for inter-assay precision were determined to be 4.2% and 5.7% for 25(OH)D3 and 25(OH)D2, respectively. The total 25(OH)D was calculated by the sum of 25(OH)D2 and 25(OH)D3.

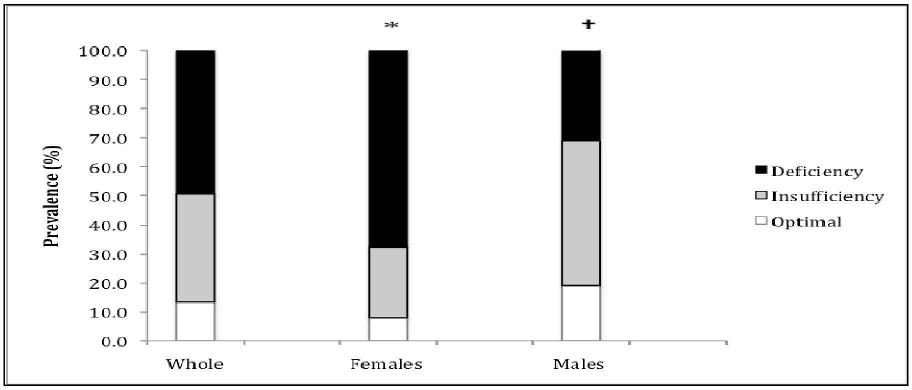
The sample size was calculated to be around 500 based on the estimated 30% prevalence of vitamin D deficiency in Bahrainis. Vitamin D status was assessed according to the recommendation by the Institute of Medicine (2011) that defined vitamin D deficiency, insufficiency and optimal at serum 25(OH)D concentrations of <30 nmol/L, 30-50 nmol/L and ≥50 nmol/L, respectively[8].

Chi-square and Fisher's exact analysis and student t-test were used for comparison. Statistical inferences were made based on 2-sided significance level of $p<0.05$. All statistical analyses were performed using SPSS version 19.0.

RESULT

Mean total serum 25(OH)D concentration was 27.9±19.3 nmol/L and it was significantly lower in females than males (21.6±19.0 vs. 34.2±23.7, p=<0.001).

The prevalence of vitamin D insufficiency and deficiency was 185 (37%) and 247 (49.4%), respectively. As illustrated in figure 1, the prevalence of vitamin D insufficiency was significantly higher in males than females (p=<0.0001), whereas the prevalence of vitamin D deficiency was significantly higher in females than males ($p<0.005$).



* Higher prevalence of vitamin D deficiency than males (p=<0.0001),
✝ Higher prevalence of vitamin D insufficiency than females (p<0.005)

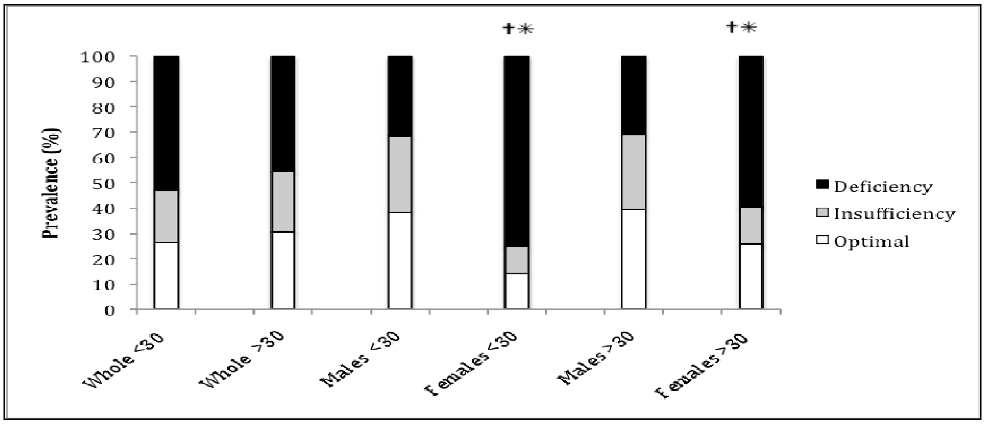
Figure 1: Prevalence of Vitamin D Deficiency and Insufficiency of Whole Participants, Males and Females

Serum levels of 25(OH)D2 and 25(OH)D3 and total 25(OH)D in younger age group (<30 years) and older age group (>30 years) are shown in Table 1. The total 25(OH)D was significantly higher in older participants than the younger ones. The total serum 25(OH)D was significantly lower in females <30 years than females >30 years (p=<0.0001). In addition, total serum 25(OH)D levels were significantly lower in females than males in both age groups (p=<0.0001). Furthermore, the prevalence of vitamin D deficiency was significantly higher in females <30 years than females >30 years and it was also significantly higher in females than males in both age groups (p=<0.001), see figure 2.

Table 1: Serum Levels of 25(OH)D3, 25 (OH)D2 and Total Vitamin 25(OH)D, Prevalence of Vitamin D Insufficiency and Deficiency in Males and Females According to Age

Vitamin D Metabolites (nmol/L)	**Whole Participants**			**Male**			**Female**		
	<30 (n=262)	**>30 (n=238)**	**P value**	**<30 (n=133)**	**>30 (n=117)**	**P value**	**<30 (n=129)**	**>30 (n=121)**	**P value**
25(OH)D3	25.0±13.7	28.1±018.7	0.006	32.8±18.7	33.2±21.2	0.746	17.2±8.7*	23.9±16.3*	0.02
25(OH)D2	1.3 ±0.85	1.43±1.2	0.450	1.32±0.93	1.42±0.95	0.550	1.33 ±0.77	1.43±1.1	0.725
Total 25(OH)D	26.1±18.1	29.7±20.4	0.006	33.9±23.7	34.5±20.9	0.487	18.3±12.5*	24.8±19.9*	0.001

All results are presented as geometric means (SD) *significantly lower than males P=<0.001



* Higher prevalence of vitamin D deficiency than age group >30 years old. (p<0.0001)
✝ Higher prevalence of vitamin D deficiency than males at both age groups (p=<0.001)

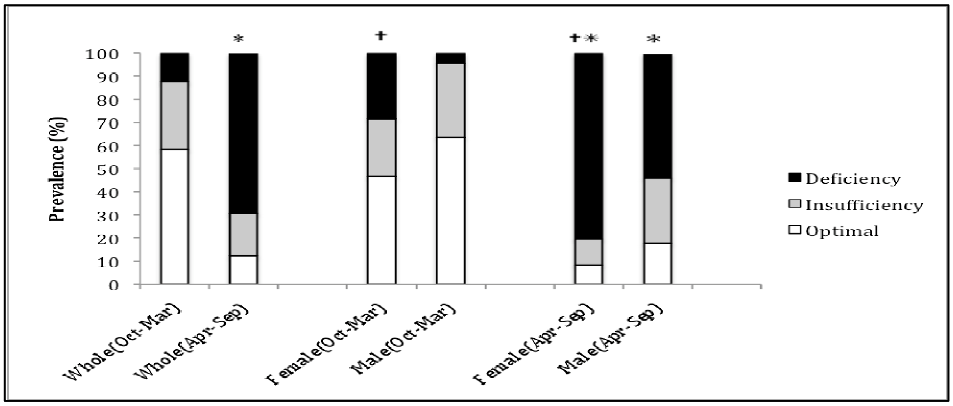
Figure 2: Prevalence of Vitamin D Deficiency and Insufficiency in Whole Participants, Males and Females According to Age Group

Total serum 25(OH)D levels were significantly lower during April to September season than October to March, see table 2. In addition, as illustrated in Figure 3, the prevalence of vitamin D deficiency was significantly higher during April to September than October to March (p=<0.0001). Furthermore, the prevalence of vitamin D deficiency was significantly higher during April to September than October to March in males and females (p=<0.0001). The prevalence of vitamin D deficiency was also higher in females than males the whole year round (p=<0.0001).

Table 2: Seasonal Variation of 25(OH) Vitamin D Levels

	Whole Participants			Male			Female		
Vitamin D Metabolites (nmol/L)	**April-September (n=325)**	**October-March (n=175)**	**P value**	**April-September (n=135)**	**October-March (n=115)**	**P value**	**April-September (n=190)**	**October-March (n=60)**	**P value**
25(OH)D3	20.0±15.8	33.1±17.6	<0.0001	25.9±14.8	40.1±25.0	0.001	16.6±13.5*	24.6±12.1*	0.001
25(OH)D2	1.40±0.96	1.3±0.94	0.487	1.4±1.21	1.33±1.1	0.818	1.4±1.1	1.4±0.76	0.395
Total 25(OH)D	21.1±17.4	34.7±21.2	<0.0001	27.0±15.1	41.4±32.3	0.001	17.6±14.5*	25.6±23.5*	0.001

All results are presented as geometric means (SD) *significantly lower than males (P=<0.0001)



* Higher prevalence of vitamin D deficiency than Oct-Mar (p<0.0001)
✝ Higher prevalence of vitamin D deficiency than males in whole year round (p<0.0001)

Figure 3: Prevalence of Vitamin D Deficiency and Insufficiency of Whole Participants and in Males and Females Bahrainis According to Seasons

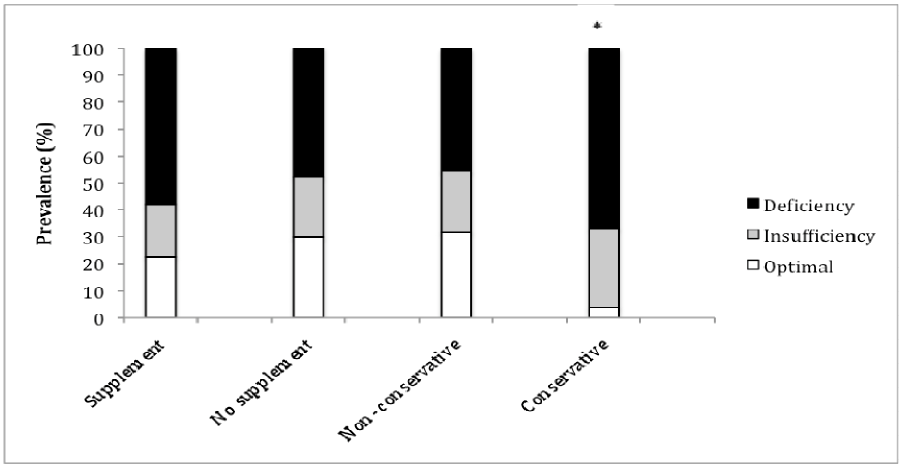
There was no significant difference in serum total 25(OH)D between vitamin D and calcium users compared to non-users, see table 3. In addition, the prevalence of vitamin D deficiency was not significantly different between vitamin D and calcium users compared with non-users, see table 3 and figure 4.

Table 3: Serum Levels of 25 (OH)D3, 25 (OH)D2 and Total Vitamin 25 (OH)D According to the Vitamin D and Calcium Supplement Users and Non-Users and Clothing Habits in Women

Vitamin D Metabolites (nmol/L)	Supplement Users (n=62)	Non-users (n=437)	P value	Semi-Conservative (n=16)	Conservative (n=224)	P value
25(OH)D3	27.6± 19.6	25.7± 18.7	0.08	22.8±10.5	18.4±14.5	0.03
25(OH)D2	1.5±1.2	1.30±0.8	0.354	1.4±0.66	1.4±1.2	0.452
Total 25(OH)D	29.1 ±17.2	27.0±21.4	0.09	23.2±19.1	20.0±18.9	0.04

All results are presented as geometric means (SD)

Serum levels of total 25(OH)D was significantly lower in females with conservative compared with non-conservative clothing style, see table 3. In addition, the prevalence of vitamin D deficiency was significantly higher in women with conservative clothing style than those with non-conservative clothing style, see table 3.



* Higher prevalence of vitamin D deficiency than non-conservative clothing style (p=0.002)

Figure 4: Prevalence of Vitamin D Deficiency and Insufficiency in Vitamin D and Calcium Supplements Users and Non-Users and Women with Non-Conservative and Conservative Clothing Style

In all figures illustrated in this article black part of the bars represents the percentage of participants with total 25OH)D <30.0 nmol/L (deficiency), gray part of the bar represents the percentage of participants with total 25(OH)D between 30-50 nmol/L (insufficiency) and white part of the bar represents the percentage of participants with total 25(OH)D >50 nmol/L (Optimal).

DISCUSSION

Vitamin D status has been investigated in different populations and its deficiency is being recognized worldwide.

In this study the classification of optimal, insufficiency and deficiency of vitamin D was based on the recommendation of the Institute of Medicine that serum 25 (OH)D level of 50 nmol/L is adequate for bone health and serum 25(OH)D level of <30 nmol/L is an indicator of vitamin D deficiency that may contribute to bone related disorders. This classification was based on assessment of more than one thousand studies, reports and testimony from scientists in different ethnic groups[8].

A marked gender difference in vitamin D status was observed in this study, as the prevalence of vitamin D deficiency was consistently and significantly higher in females than males. This marked gender difference is consistent with other publications[1]. Higher vitamin D level in males seen in this study could be explained that males spend more time outdoors and women wear sun protective clothing and avoid sun exposure.

In this study, vitamin D deficiency was significantly higher in younger age (<30) than older age (>30). These results are not consistent with a large number of studies in Europe and US suggesting that the vitamin D deficiency are significantly higher in the older population than the younger ones[22-24]. The reason for the higher prevalence of vitamin D deficiency may be due to the fact that younger people have less outdoors physical activities and spend more time indoor whereas older people tend to have more outdoor physical activities[25].

In general there is a marked seasonal variation of serum 25(OH)D levels in different regions of the world, especially in areas of high latitude (>40°N), lowest during the winter months and highest in late summer and the global prevalence of vitamin D deficiency is reported to be higher during the winter than during the summer months[9,26-27].

In this study, serum total 25(OH)D concentrations in all ages averaged 41.5 nmol/L in October to March and 21.1 nmol/L in April to September. Vitamin D deficiency was significantly higher during April to September than October to March, which is consistent with other studies[28-30]. Vitamin D deficiency has been reported to be around 40-87% in the Middle Eastern populations[28]. This finding could be attributed to outdoor activities seen from October to March; whereas during the summer, the outdoor activities are very limited due to high humidity and extreme heat. Vitamin D deficiency has been surprisingly reported to be much more common in people living in sunny countries such as Italy, Spain and Greece than among those living in Scandinavian countries where sunlight exposure is less[29-30].

The latitude of Bahrain is 26°N and there should be a sufficient vitamin D3 synthesis in the skin all year round but it has been suggested that continued skin exposure to UV radiation could also lead to conversion of pre-vitamin D3 and vitamin D3 to inactive photoproducts[31]. In addition, Bahrainis and Middle-Eastern in general have darker skin textures with a high production of melanin in response to UV radiation, it has been suggested that by absorbing electromagnetic radiation melanin competes with 7-dehydrocholesterol for UVB photons[31-32]. Therefore, the levels of UVB reaching the skin site for vitamin D synthesis can be reduced by higher skin's melanin content[31-34].

In this study the prevalence of vitamin D deficiency was not significant among those participants using calcium and vitamin D supplements than non-users suggesting that vitamin D supplementation has no major effect on vitamin D levels. However, these results may not be conclusive as the number of calcium and vitamin D supplement users were much less compared to non-users.

As expected a higher prevalence of vitamin D deficiency was found among women with conservative clothing habits than those with non-conservative style. White and lighter cotton fabric clothing are less effective in blocking ultraviolet than long and black clothing[35]. In addition, women in this part of the world do not tend to expose themselves to sunlight avoiding the excessive heat. Therefore, it is presumed that conservative clothing and dark pigmentation could be factors affecting vitamin D level among Bahraini women and other Middle Eastern countries[19-21,33-34]. However, the results from this study may not be again conclusive as the number of women with non-conservative clothing habits were much less than participants with conservative clothing style.

One of the limitations of this study is being a cross-sectional study and the exact reasons for low vitamin D level in Bahrainis cannot be proved, only the association of gender, age, season and clothing could be presumed. A longitudinal study may be required to examine exact causes of vitamin D deficiency observed in this study. In addition, this study did not assess parathyroid hormone, alkaline phosphatase, phosphorus and calcium levels to exclude any cases of secondary hyperparathyroidism. However, any participant with history of calcium and vitamin D deficiency and hyperparathyroidism were excluded[36].

CONCLUSION

This is the first population-based study in Bahrain that indicates vitamin D deficiency. It is recommended that fortification of food with vitamin D on a national basis is necessary to overcome such low levels of vitamin D in Bahrainis. Further molecular studies are also required to investigate the association of single nucleotide polymorphisms of vitamin D receptors or vitamin D binding protein that may contribute to the low plasma 25(OH)D levels among Bahrainis.

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