Original Article

The Prevalence and Determinants of Vitamin D Status among Older Adults: Data from a Longitudinal Aging Study

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Abstract

Background: Aging is identified as a risk factor for vitamin D deficiency (VDD) therefore this investigation was designed to determine the prevalence of VDD and its determinants in a sample of older adults. **Methods:** The data of this study were obtained from the baseline wave of the Longitudinal Aging Study (LAS). Demographic, past medical history, medication history, and smoking behavior were collected using an interview approach. The physical activity and nutritional status of the participants were assessed using a standard questionnaire. Anthropometric indices were measured according to a standard protocol then body mass index (BMI) was calculated. Serum vitamin D and calcium levels were measured by autoanalyzers. Univariate and multiple logistic regression models were applied to detect the associated factors with VDD. **Results:** Mean age of the participants was 71.82 (SD = 7.63) years. A total of 1319 people participated in our study, and 51.16% (n = 688) were female. A total of 8.42% (n = 111) of the participants had VDD and 17.06% of them (n = 225) had insufficient vitamin D levels. In the multivariable logistic regression model, the age group of 70–79 years in comparison with the age group of 60–69 years had a 43% less chance of VDD. Furthermore, being overweight (OR = 0.36, P = 0.01) and obese (OR = 0.35, P = 0.02), and taking vitamin D supplements (OR = 0.31, P = 0.04) were significantly associated with VDD. **Conclusions:** Our results showed that 25% of older adults had vitamin D deficiency or insufficiency. In addition, some modifiable lifestyle factors were associated with VDD. Given that, old age is considered a risk factor for VDD. Therefore, detection and improvement of VDD may be a preventive measure in at-risk subjects.

Keywords: *Older adults, prevalence, prevention, vitamin D deficiency*

Introduction

As a result of socioeconomic development, life expectancy steadily increased in the past few decades and this increment is expected to continue in industrialized countries as well as in developing countries. According to a United Nations report, it is estimated that the number of people aged 65 years and older rise from 0.7 billion (9%) in 2019 to 1.5 billion (16%) in 2050.[1] According to the United Nations definition, if a population over 60 years old is beyond 7% in a country that country is considered to be aged herein, it is estimated that Iran experienced a sudden increase in the elderly population between 2030 and 2040.[2]

The aging process is associated with lifestyle, socioeconomic, and biological changes, which is related to growing diseases and injuries, which can impose a growing disease burden on the healthcare system worldwide.[3]

Therefore, in this context, the World Health Organization (WHO) and other global organizations emphasize the promotion of a concept known as “successful” or “healthy” aging.[2] Most studies investigated the role of modifiable lifestyle factors such as moderate physical activity, a high-quality diet including dietary components such as vitamin D, and maintaining a normal body weight for achieving “successful” or “healthy” aging.[2]

Vitamin D is a steroid hormone, which is mostly synthesized in the skin following ultraviolet B (UVB) sunlight exposure and to a lesser extent from the diet.[4] Also, calcium absorption from the intestine is mediated by the active transport vitamin D-dependent and passive diffusion.[5] Geographical location related to the intensity of the solar ultraviolet (UV), darker skin pigmentation, obesity, malabsorption, and advanced age were identified as risk factors for vitamin D deficiency.[6]

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Older adults are particularly at higher risk for vitamin D deficiency because of the debilitated ability of dermal synthesis following exposure to UVB sunlight, activation of vitamin D in the kidney, and age-related behavioral changes such as clothing, less outdoor exercise, and activity and dietary patterns such as decreased food quality, quantity, and variety.[7]

There is no consensus on the optimal level of vitamin D; therefore, there are various designations of 25(OH) D concentration cutoffs for vitamin D deficiency (VDD). The North American Institute of Medicine (IOM) and the UK Scientific Advisory Committee on Nutrition (SACN) consider a threshold of 30 nmol/L while European Food Safety Authority (EFSA) and the Endocrine Society (ES) established a threshold of 50 nmol/L.[8]

A study performed by Aspell *et al*.[9] on 6004 adults, aged >50 years from the English Longitudinal Study of Ageing (ELSA), showed that the overall prevalence of VDD was 26.4% and 58.7% based on IOM criteria and ES definitions, respectively.

Since recent studies show a high prevalence of VDD even in areas of the world with high sunlight exposure including Iran, and association of low vitamin D with many diseases, especially in older adults, therefore, the present study was designated for the prevalence of calcium deficiency and VDD and investigated the demographical, seasonal, and lifestyle factors among older adults of Birjand (a sunny city in eastern Iran, capital of South Khorasan province,) in 2019.

Also, we found a recent study by Mansouri *et al*.[10] in 2021 on 600 Iranian men and women 60 years of age and older who attended health centers in Tehran; however, the present study has population-based multistage stratified cluster random designation on more than twice the population (1319 subjects) than mentioned study furthermore, demographical, nutritional status, physical activity level, and lifestyle factors were considered seasonal variation in two season of Fall and winter due to dependency of vitamin D on sunlight.

Methods

Study design, population, and sampling

This study is a cross-sectional approach to data of the baseline of the Brijand Longitudinal Aging Study (BLAS). The sampling of this study was a multistage stratified cluster random method and the sample was representative of older adults ≥60 years, who live in Birjand. Inclusion criteria of the study were age ≥60 years and willingness to participate in the study and exclusion criteria were very short life expectancy and illiterate. The sampling models and data-gathering methods of this study were discussed in more detail elsewhere.[11]

Data acquisition

Demographic data such as age, education levels, employment, and smoking status (cigarette and hookah) were collected using a validated questionnaire. History of chronic diseases such as diabetes mellitus, hypertension, chronic kidney disease, (CKD), and chronic obstructive pulmonary disease (COPD) and medication history were collected. This information was obtained by asking the participants and their accompanied related informants as well as by checking the medical documents of the participants by the researchers. Levels of physical activity were evaluated by LASA Physical Activity Questionnaire (LAPAQ). The metabolic equivalents (METs) of each physical activity were extracted from the international table of METs.[12] The height of the participants was measured in an upright position along with the vertical axis and weights were measured with the least clothes without any headcover and shoes to the nearest 0.5 cm and 0.1 kg by a calibrated stadiometer (Seca, Hamburg, Germany,). All anthropometric measurements were performed according to the National Health and Nutrition Examination Survey (NHANES) anthropometric protocol.[13] Body mass index (BMI) was calculated by dividing weight by the square of height in meters.

A mini nutrition assessment (MNA) questionnaire was utilized for screening malnutrition in the participants. The application of this tool was popular in clinical and research settings for a rapid national evaluation of older adults. The tool has 18 items and the lowest score of the tool is zero and the highest score is 30. The validation of the Persian version of MNA was approved in Iran[14] Blood samples were collected after at least 12-h overnight fasting. The serum was separated from the clot at 6000 rpm centrifuging as soon as possible after samples were collected. Then the serums were stored at less than −70°C temperature. Calcium and vitamin D were measured with the calorimetry method (Pars Azmoon Kit with Authoanalyzer (Prestige 241, Tokyo, Japan) and intra-assay coefficient = 1.07) and Vitamin D was measured by ELISA method [kit of 25-OH vitamin D, Padtan Gostar Isar (PGI Co.) using Ap22 Speedy Auto-analyzer (Rome, Italy)] with an intra-assay coefficient equal to 5.97.

Protocol of analysis

The serum levels of 25(OH) vitamin D <12 ng/mL were considered as VDD, and 12–20 ng/mL were considered as insufficient serum vitamin D. Survey analysis was standardized according to WHO population 2000–2025 to estimate the prevalence of insufficient and VDD. The weight of the age group in Birjand was also considered in the survey. Associated factors of VDD were evaluated in univariate and multiple logistic regression models. The backward approach was considered for multiple regression models. Sex remained in the model despite it being removed in a backward approach. All analyses were performed using STATA12 (StataCorp Texas, USA).

Ethical consideration

This study was approved by the Research Ethical Committee of the Endocrine and Metabolism Research Institute (EMRI) of Tehran (Ethical code: IR.TUMS.EMRI.REC.1396.00158) and Birjand University of Medical Sciences (BUMS) Research Committee (Ethical code: IR.bums.REC.1395.215). All the participants signed the informed consent. In cases of cognitive impairment (AMTS ≤6), informed consent was also signed by the official guardian of the participants.

Patient consent

Informed consent was obtained from all participants.

Results

A total of 1319 subjects were monitored for VDD. The mean age of the participants was 71.82 (SD = 7.63) years. The mean vitamin D level was 31.16 (SD = 16.00) ng/mL and the mean serum calcium level was equal to 9.26 (SD = 0.46) mg/dL. Of the total participants, 688 (52.16%) were women. Only 111 (8.425%) of the participants had a deficient serum level of vitamin D, (60; 8.72% of women and 51; 8.08% of men), 225 (17.06%) of the participant had insufficient levels of vitamin D (96; 13.95% of women and 129; 20.44% of men), and 983 (74.53%) had a sufficient serum level of vitamin D (532; 77.33% of women and 451; 71.47% of men). Only 101 (7.66%) of the participants used vitamin D supplements. There was a statistical difference between the mean serum vitamin D in those whose samples were collected in fall than in those whose serum samples were collected in winter (31.33, SD = 16.01 ng/mL in group collected in fall and 30.31, SD = 15.97 mg/dL in winter, $P = 0.04$). The serum level of vitamin D was lower in subjects who were smokers than those who were not a smoker (26.52; SD = 13.89 vs. 31.52; SD = 16.10 ng/mL), respectively. Normally, a history of vitamin D supplement intake was more common in those with normal than lower serum levels of vitamin D (11.47% vs. 4.61% and $P < 0.001$) [Table 1].

The WHO population age-standardized prevalence of VDD was higher in males than females (7.98%; 5.09%–12.30% in men and 7.60%; 2.26%–12.66% in women). The highest age-standardized prevalence of VDD was observed in women in the age group of 60–69 years old (10.77%; 95% CI 7.9–14.38) [Table 2].

In univariate logistic regression models, there was a negative association between VDD and being overweight (odds ratio for being overweight in comparison to low body weight was 0.421, P value = 0.031, use vitamin D supplements). In the multivariable logistic regression model, there was a negative association between VDD and age groups as well as being overweight or obese and vitamin D supplementation intake [Table 3].

Discussion

Our result showed that 8.42% of the participants had a deficient serum level of vitamin D <12 ng/mL, which is similar to the study conducted by Pellicane *et al*. (2011)[15] on inpatients (n = 101) admitted to the Rehabilitation Institute of Chicago that 8.1% had vitamin D deficiency. In contrast, Kader *et al*. (2019)[16] showed that out of 6774 adult participants, 83.8% of women and 18.2% of men population (10–91 years old) who were admitted to Karapınar city, in Turkey had VDD. These discrepancies between our study and other studies can be attributed to the effect of latitude because people who live at lower latitudes may have more sun exposure and a lower prevalence of VDD. Also, the measurement methods used in these studies (tandem-mass spectrometry, radioimmunoassay, and automated immunoassay systems)[17] could be other reasons for these discrepancies

There was a statistical difference between the mean of serum's vitamin D in those whose samples were collected in fall than in those whose serum samples were collected in winter.

Our result is almost similar to a previous study conducted by Hoteit *et al*. (2014).[18] In their study, 25(OH) D concentrations were lower in the winter (20.1 ± 9.2 ng/mL) compared with the fall (24.8 ± 10.4 ng/mL) 9147 Lebanese outpatients. However, this is in contrast with Boyages and Bilinski (2012)[19] that reported VDD was prevalent in summer and increased in spring but not in winter.

These differences could be due to the dependency of vitamin D production on sunlight. The seasonal variation previously has been reported in vitamin D concentrations and the seasonal variation itself depends on latitude.[20]

Smoking was more common in subjects who had low levels of vitamin D than those who had a normal level of serum vitamin D.

Our result is in line with Jiang *et al*. (2016).[21] In this study, there were 612 Guangzhou residents aged 50 years or older. However, it is in disagreement with the study conducted by Scragg *et al*. (1992)[22] that smoking had no correlation with 25(OH) D levels. One possible explanation is the direct effect of chemicals in tobacco which may influence the metabolism and function of vitamins as there is some evidence for the change in some genes in the metabolic pathway of vitamin D.[23] Also, one more reason is that smokers usually have bad lifestyles including low physical activity, bad dietary habits, and reduced sun exposure, which can influence the synthesis of vitamin D.[23]

Our study indicated that the prevalence of VDD was higher in males than females. This is in line with the longitudinal study done by Elizondo-Montemayor *et al*. (2017)[20] on

Table 1: Comparison of demographic and anthropometric characteristics between low and normal vitamin D groups

Variables	Total (*n*=1319)	Deficient (*n*=111) (Vit D <12 ng/mL)	Insufficient (*n*=225) (12 ≥Vit D <20 ng/mL)	Sufficient (*n*=984) (Vit D ≥20)	*P*
Sex *n* (%)					
Female	688 (52.16)	60 (54.05)	96 (42.67)	532 (54.12)	0.008
Male	631 (47.84)	51 (45.95)	129 (57.33)	452 (45.88)	
Age groups (%)					
60-69 years	645 (48.90)	64 (57.66)	120 (53.33)	461 (46.90)	
70-79 years	466 (35.33)	32 (28.83)	69 (30.67)	365 (37.13)	0.114
80+years	208 (15.77)	15 (13.51)	36 (16.00)	157 (15.97)	
BMI *n* (%)					
Underweight	62 (4.70)	9 (8.11)	13 (5.78)	40 (4.07)	
Normal	468 (35.45)	48 (43.24)	71 (31.56)	349 (35.50)	0.136
Overweight	510 (38.67)	34 (30.63)	91 (40.44)	385 (39.17)	
Obese	279 (21.14)	20 (18.02)	50 (22.22)	209 (21.26)	
Current Smoker *n* (%)	95 (7.20)	9 (8.11)	27 (12.00)	59 (6.00)	0.007
Season *n* (%)					
Fall	1,108 (84.00)	84 (75.68)	193 (85.78)	831 (84.54)	
Winter	211 (16.00)	27 (24.32)	32 (14.22)	152 (15.46)	0.039
MNA *n* (%)					
Well nourished	965 (73.16)	80 (72.07)	171 (76.00)	714 (72.63)	
At risk of malnutrition	337 (25.55)	30 (27.03)	51 (22.67)	256 (26.04)	0.850
Malnourished	17 (1.29)	1 (0.90)	3 (1.33)	13 (1.32)	
Vit D supplement *n* (%)	101 (7.66)	3 (2.70)	5 (2.22)	93 (9.46)	<0.001
CKD *n* (%)					
GFR ≥60 *	315 (23.88)	27 (24.32)	57 (25.33)	231 (23.50)	
30≤ GFR <60*	897 (68.01)	75 (67.57)	153 (68.00)	669 (68.06)	0.912
GFR <30*	107 (8.11)	9 (8.11)	15 (6.67)	83 (8.44)	
Positive HX of COPD *n* (%)	75 (5.69)	53 (5.39)	15 (6.67	7 (6.31)	0.725
Physical Activity *n* (%)					
First quartile	328 (24.87)	26 (23.42)	45 (20.00)	257 (26.14)	
Second quartile	328 (24.87)	27 (24.32)	62 (27.56)	239 (24.31)	0.494
Third quartile	333 (25.25)	31 (27.93)	54 (24.00)	248 (25.23)	
Fourth quartile	330 (25.02)	27 (24.32)	64 (28.44)	239 (24.31)	
Calcium serum mean (SD) mg/dL	9.26 (0.46)	9.23 (0.41)	9.27 (0.44)	9.26 (0.48)	0.801

*mL/min/1.73m^2. BMI: Body Mass Index, MNA: Mini Nutritional Assessment, Vit D: Vitamin D, CKD: Chronic Kidney Disease, COPD: Chronic Obstructive Disease, HX: History

healthy adults 55–86 years old in the northeastern part of Mexico who found women had higher 25(OH) D levels than men. However, our results are in contrast with the study done by Huang *et al*. (2017).[24] In this study, 30.6% of men and 57.7% of women of 170 healthy volunteers aged 65 or older in rural areas of southern Taiwan had a low vitamin D status. Since Abboud *et al*.[25] indicated >30 min/day of physical exercise has a significant protective effect against VDD in men but not in women, therefore, a lack of regular physical activity (<30 min/day) in men can be a risk factor. Also, older male adults refused to take a sufficient dosage of a vitamin D supplement, which may have led to continuous deficiency.

In this study, there was a negative association between VDD and being overweight and obesity.

Our findings are similar to those of cross-sectional observational study conducted by Sousa-Santos *et al*. (2018)[26] in Portugal that was done on 1447 individuals aged 65 years or older. They showed that there was an inverse association between obesity with serum 25(OH) D concentrations. However, our study is in contrast with the study done by Al Hayek *et al*. (2018)[27] in Lebanon on 344 subjects (50% men and 50% women) aged between 20 and 74 years that indicated BMI was not associated with vitamin D status. This is because vitamin D is a fat-soluble vitamin and adipose tissues act as a reservoir for vitamin D therefore leading to the sequestration of vitamin D by fat tissue and inadequate serum 25(OH) D concentrations in obese individuals.[28] Another mechanism that can affect serum vitamin D levels can be less outdoor activity in obese individuals and herein less skin exposure to sunlight.[29]

Our results indicated that the highest age-standardized prevalence of VDD was observed in women in the age group of 60–69 years old and the multivariable logistic

Table 2: The crude and WHO population age-standardized prevalence of levels of vitamin D in the older population of Birjand city

Variables		Female			Male			Both sex		
		Crude prevalence		Age-Standardized prevalence (%)	Crude prevalence		Age-Standardized prevalence (%)	Crude prevalence		Age-Standardized prevalence (%)
Age groups	Vitamin D condition	*n* (%)	Point Estimation (%)	95% CI	*n* (%)	Point Estimation	95% CI	*n* (%)	Point Estimation (%)	95% CI
60-69 years	Sufficient	273 (74.18)	74.28	69.54-78.51	189 (67.99)	67.41	61.73-72.79	461 (71.47)	71.14	67.48-74.54
	Insufficient	55 (14.95)	14.95	11.63-19.00	65 (23.38)	23.96	19.27-29.39	120 (18.60)	19.14	16.25-22.40
	Deficient	40 (10.87)	10.77	7.98-14.38	24 (8.63)	8.63	5.83-12.59	64 (9.92)	9.72	7.66-12.28
70-79 years	Sufficient	195 (82.63)	82.94	77.23-87.45	170 (73.91)	74.01	67.62-79.51	365 (78.33)	78.46	74.24-82.15
	Insufficient	28 (11.86)	11.67	7.97-16.77	41 (17.83)	18.10	13.41-23.96	69 (14.81)	14.95	11.81-18.74
	Deficient	13 (5.51)	5.39	3.03-9.38	19 (8.26)	7.90	4.97-12.32	32 (6.87)	6.59	4.59-9.39
80+ years	Sufficient	64 (76.19)	77.35	65.80-85.84	93 (75.00)	74.10	64.62-81.72	157 (75.48)	75.87	68.61-81.90
	Insufficient	13 (15.48)	14.85	8.14-25.54	23 (18.55)	18.03	11.78-26.60	36 (17.31)	16.40	11.81-18.74
	Deficient	7 (8.33)	7.80	3.37-17.02	8 (6.45)	7.87	3.82-15.51	15 (7.21)	7.73	4.43-13.17
All age	Sufficient	532 (77.33)	78.34	71.41-83.97	451 (71.47)	73.15	67.33-78.27	983 (74.53)	75.87	71.42-79.82
	Insufficient	96 (13.95)	14.06	9.51-20.30	129 (20.44)	18.87	14.58-24.06	225 (17.06)	16.41	13.12-20.34
	Deficient	60 (8.72)	7.60	4.46-12.66	51 (8.08)	7.98	5.09-12.30	111 (8.42)	7.72	5.44-10.84

regression model showed a negative association between VDD and age groups.

Our result is in agreement with the study by Kader *et al*. (2019),[16] which was done on 6774 adult (10–91 years old) admitted to Karapınar public hospital, Turkey. Our results, however, are in disagreement with a retrospective study conducted in Turkey, which found that the lowest VDD was in the age group of 0–10 years and the highest VDD was in the age group of 10–40 years old.[30] A possible explanation is that skin production of vitamin D due to UV radiation exposure, decreases with aging.[31] In addition, since the main source of vitamin D is the sun exposure and the diet, Muslim women who wear veils and clothes gain inadequate UVB radiation from the sun also; women have higher body fat compared with men and are at higher risk of hypovitaminosis in a sunny city such as Birjand.[32]

In conclusion, 25% of elderly individuals had 25(OH) D insufficiency or deficiency, and some modifiable lifestyle factors were associated with VDD or insufficiency. Vitamin D can be acquired from the diet or skin exposure to solar UVB radiation. On the other hand, there is growing evidence that living in areas with abundant sunlight may not be possible to attain adequate amounts of vitamin D. Therefore, education about the importance of consuming food sources high in vitamin D and the adoption of better nutrition seems essential.

Study limitations and strength

Since this study had a cross-sectional design, seasonal variation of 25(OH) D levels has not been considered during data analysis. A second limitation was that the precise geographic status of Birjand has not been determined consequently the degree of exposure to the sun is unknown. A third limitation was that only subjects in urban areas were studied and the vitamin D status of individuals in rural areas was unavailable therefore, the study may not be representative of the general population of South Khorasan.

The strength of this study is monitoring a large sample size of the elderly people, a population category that has not been particularly well-studied previously in South Khorasan to assess vitamin D status and related factors. Another strength of this study is investigating a large number of confounders and associated diseases.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Table 3: Logistic regression for risk factors of low vitamin D status

Variables	Univariate Analysis				Multiple Analysis			
	Odds Ratio		95% CI Odds Ratio	*P*	Odds Ratio		95% CI Odds Ratio	*P*
Age								
60-69 years			Reference				Reference	
70-79 years	0.669	0.430	1.042	0.075	0.630	0.402	0.988	0.044
80+years	0.706	0.393	1.270	0.243	0.592	0.323	1.085	0.090
Sex (male/female)	0.920	0.623	1.359	0.677	0.776	0.514	1.173	0.229
Season (winter/fall)	1.789	1.128	2.837	0.013	1.800	1.128	2.873	0.014
BMI								
Underweight			Reference				-	
Normal	0.673	0.313	1.499	0.312	0.645	0.297	1.401	0.268
Overweight	0.421	0.191	0.925	0.031	0.358	0.159	0.804	0.013
Obese	0.455	0.196	1.054	0.066	0.353	0.147	0.848	0.020
MNA								
Well-nourished			Reference				-	
At risk of malnutrition	1.081	0.697	1.677	0.728	-	-	-	-
Malnourished	0.691	0.091	5.281	0.722	-	-	-	-
Vitamin D Supplement (yes/no)	0.315	0.098	1.01	0.051	0.309	0.096	0.997	0.049
Current Smoker (yes/no)	1.151	0.563	2.355	0.700	-	-	-	-
CKD								
GFR ≥60			Reference		-	-	-	-
30 ≤GFR <60	0.973	0.614	1.542	<0.001	-	-	-	-
GFR <30	0.980	0.445	2.155	0.002	-	-	-	-
Physical Activity								
First quartile			Reference				-	
Second quartile	1.042	0.594	1.827	0.886	-	-	-	-
Third quartile	1.192	0.691	2.056	0.527	-	-	-	-
Fourth quartile	1.035	0.590	1.815	0.904	-	-	-	-
Calcium Serum	0.873	0.575	1.325	0.523	-	-	-	-

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Conflicts of interest

There are no conflicts of interest.

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