Original article

Evaluation of Vitamin D Status Among Adult Population in Tripoli Region, Libya

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ABSTRACT

Background and aims*. Vitamin D deficiency is a pandemic public health concern as it is highly prevalent in all parts of the world. The higher rates of hypovitaminosis in the sunniest areas of the world have been reported including Libya. The study aimed to evaluate the prevalence of vitamin D deficiency among adult population in Tripoli region, Libya, and evaluating some contributing factors including age, gender and obesity.* ***Methods.*** *A cross sectional study was conducted among 293 subjects (129 males and 164 females) whose ages lied between 20-50 years in Tripoli region, Western Libya. Vitamin D levels were biochemically estimated by using enzyme immunoassay method. BMI was calculated for all participants (weight in kilogram / height in meter square).* ***Results.*** *Overall, the prevalence of vitamin D deficiency was 55.63%, out of which 25.58% in males and 79.26% in females, while 19.45% of participants had vitamin D insufficiency (23.25% in males and 16.46% in females). Furthermore, 24.91% of participants had vitamin D Adequacy (51.16% in males and 4.26% in females). The highest prevalence of vitamin D deficiency was in the age group 41- 50 years. The means of vitamin D deficiency were 13.93±3.46and 11.32± 4.16 in males and females respectively, and were statistically difference. Furthermore, there was significant difference in the means of vitamin D levels among the three groups (healthy weight, overweight and obese subjects).* ***Conclusion.*** *High prevalence rate of vitamin D deficiency in Tripoli population, western Libya, and was higher in females than males especially among ages 41- 50 years. Obesity has adverse effects on vitamin D levels which contributes to severe vitamin D deficiency. Adapting proper lifestyle focused on maintaining health weight, sufficient sunlight exposure and increasing dietary intake of vitamin D can reduce the burden of vitamin D deficiency.*

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INTRODUCTION

Vitamin D is a fat-soluble vitamin that is synthesized from 7‑dehydrocholesterol in the skin upon exposure to ultraviolet B rays of sunlight. 1,25‑dihydroxycholecalciferol which is the active form of Vitamin D plays an important role in the maintenance of calcium homeostasis by binding to its receptors on its target tissues which include bone, kidney and intestine. In addition to its role in maintaining bone health, vitamin D has several important extra skeletal biochemical functions in the body including regulating immune, cardiovascular and neuroendocrine systems, and moreover, has autocrine function, on the intracellular level, facilitating gene expression [1-3]. The causes of vitamin deficiency are multiple and include indoor life style, high latitude, dark skin, insufficient skin area exposed to UVB, obesity (expanded volume of distribution), aging (reduced capacity for photosynthesis), severe liver disease, and chronic kidney disease [4,5].

Obesity is a medical condition in which excess body fat has accumulated to the extent which has a negative effect on health, leading to reduced life expectancy and/or increased health problems [6]. There is a close association between obesity and vitamin D deficiency [7,8]**.** Vitamin D in obese individuals enters into large fat depots located in the adipose tissues leading to decreased vitamin D levels. Moreover, it could be due to volumetric dilution as a result of large body size in obesity [9].

In last decade, vitamin D deficiency (VDD) has been recognized as a pandemic worldwide [10, 11]. Recent reports have shown that higher rates of hypovitaminosis in the sunniest areas of the world, including the Middle East and Asian countries, such as Qatar, Saudi Arabia, United Arab Emirates, Iran Turkey, and India [12, 13]. In 2016, Food and Agriculture Organization reported that 62% of Qatari teenager had vitamin D deficiency and 81% of Saudi girls had deficiency of vitamin D. Highest vitamin D deficiency was reported in Saudi women, up to 85% [14].

According to a systematic review and Meta-analysis study, 2020 in which 129 studies have been reviewed with 21474 subjects from 23 African countries included Libya, vitamin D deficiency was prevalent in African countries and most common was in northern African countries [15].

In a cross-sectional study in Benghazi, Libya, vitamin D deficiency was 76.1%, insufficiency was 15.2% whereas, 8.7% of subjects had sufficient vitamin D. Vitamin D deficiency was more prevalent in women than men. 58.4% of women had vitamin D deficiency, and 25% were in vitamin D insufficiency, while 26.1% of men were deficient, and 21% were insufficient vitamin D [16]. Another study from Tripoli, Libya, identified 69% of nursing mothers had vitamin D deficiency (≤20 ng/ml) and 30% of nursing mother had vitamin sufficiency (≥30 ng/ml) [17]. A study conducted in Misurata city revealed about 80% of subjects had inadequate vitamin D levels and out of which women were more susceptible to vitamin D deficiency which counted for 61.6% < 25 nmol/ L and 20.2% between 25-50 nmol/ L [18]. Majority of Libyan women wear traditional attire and have indoor lifestyle, or avoid sun exposure due to cultural customs as a study confirmed. Thus, their vitamin D intake relies greatly on the food they eat, which might not be enough to meet the requirements [16]. The study aimed to evaluate the prevalence of vitamin D deficiency among adult population in Tripoli region, Libya, and evaluating some contributing factors including age, gender and obesity.

METHODS

Study population

An observational cross-sectional study was conducted among 293 subjects (129 males and 164 females) whose ages lied between 20-50 years in Tripoli region, Western Libya, over a period of three months from May 2023 to July 2023. The study protocol was approved by Ethical Committee at Tripoli College of Medical Sciences. All participants showed their agreement and signed the consent forms. They were informed of the purpose of the study and requested to complete the questionnaires The questionnaires covered sociodemographic data (age, sex and residence), medical history, daily sunlight exposure, physical activity, smoking status, history of vitamin D or calcium supplementation, history of bone aches or pains and intake of any medications that could affect vitamin D metabolism and moreover, life style factors including food intake from major dietary vitamin D sources such as meat and their products, dairy foods, egg yolk, mushroom, fortified foods, and oily fishes.

Measurement of vitamin D levels

Serum vitamin D levels were estimated by direct ELISA kit method using vitamin D ELISA Kit (ORGENTEC Diagnostika GmbH Company - Germany). The reference value of the used kit: vitamin D deficiency: < 20 ng/ml,vitamin D insufficiency: 20 - 30 ng/ml and vitamin D sufficiency: > 30 - 100 ng/ml. Body Mass Index (BMI) (kg/$m2$) was calculated for all participants(weight in kilogram/height in meter square.

Inclusion criteria

All healthy adults for both sex (males and females) whose ages lied between 20 to 50 years.

Exclusion criteria

Subjects with chronic renal and/or hepatic diseases and those who are suffering from diseases of thyroid, digestive tract, osteoporosis, bone, skin and other diseases that affect the absorption and synthesis of vitamin D. Subjects suffering from diarrhea and those currently on or with a history of medications interfering with vitamin D metabolism, and supplemented subjects with vitamin D and calcium.

Statistical analysis

All data were subjected to statistical analysis and were presented as frequencies, percentages and means. The results were analyzed using Statistical Package for Social Sciences (SPSS) version 25. Analysis of variance (ANOVA) test was used to test the association of serum vitamin D with variables. The difference between variables were determined at p. Value = 0.05. P value < 0.05 was considered statistically significant.

RESULTS

In the present study 293 of subjects were included for both sexes (129 males and 164 females) whose ages ranged between 20-50 years.

Table 1 shows distribution of subjects according to gender and age groups. Total number of subjects who lies between 20-30 year was 89 (30.37%), out of which 43 (14.67%) males and 46 (15.69%) females. Total number of subjects between 31-40 years was 100 (34.12%), out of which 45 (15.35%) males and 55 (18.77%) females, and for those aged between 41-50 years was 104 (35.49%), out of which 41 (13.99%) males and 63 (21.50%) females.

Table 1. Distribution of subjects in accordance to gender and age groups.

Gender	Males		Females		Total	
Age groups (years)	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
20- 30 years	43	14.67	46	15.69	89	30.37
31- 40 years	45	15.35	55	18.77	100	34.12
41- 50 years	41	13.99	63	21.50	104	35.49
Total	129	44.02	164	55.97	293	100

Table 2 shows distribution of subjects according to gender and vitamin D levels (deficiency**,** insufficiency and adequacy). Total number of subjects who had vitamin D deficiency was 163 (55.63%), out of which 33 (25.58%) males and 130 (79.26%) females. Total number of subjects who had vitamin D insufficiency was 57 (19.45%), out of which 30 (23.25%) males and 27 (16.46%) females, and for those who had adequate vitamin D was 73 (24.9%), out of which 66 (51.16%) males and 7 (4.26%) females.

Table 2. Distribution of subjects according to gender and vitamin D status.

Vitamin D levels ng/ dl	**Gender**					
	Males		**Females**		**Total**	
	Frequency	%	**Frequency**	%	**Frequency**	%
Deficiency < 20 ng/ dl	33	25.58	130	79.26	163	55.63
Insufficiency (20-30) ng/ dl	30	23.25	27	16.46	57	19.45
Adequacy ≥ 30 ng/ dl	66	51.16	7	4.26	73	24.91
Total	129	100	164	100	293	100

Table 3 illustrates distribution of subjects according to ages and vitamin D status. Total number of subjects who had vitamin D deficiency was 163 (55.63%), out of which (35 (11.94%), 46 (15.69%) and 82 (27.98%) for the age groups 20- 30 years, 31- 40 years and 41- 50 years, respectively. Subjects who had vitamin D insufficiency was 57 (19.45%) , out of which 12 (4.05%), 30 (10.23%) and 15 (5.11%) for the age groups 20- 30 years, 31- 40 years and 41- 50 years, respectively. Subjects who had vitamin D adequacy was 73 (24.91%), out of which 42 (14.33%), 24 (8.19%) and 9 (3.07%) for the age groups 20- 30 years, 31- 40 years and 41- 50 years, respectively.

Table 3. Distribution of subjects according to ages and vitamin D status.

Vitamin D levels ng/ dl	**Age groups**							
	20- 30 years		31- 40 years		41- 50 years		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Deficiency < 20 ng/ dl	35	11.94	46	15.69	82	27.98	163	55.63
Insufficiency (20-30) ng/ dl	12	4.05	30	10.23	15	5.11	57	19.45
Adequacy ≥ 30 ng/ dl	42	14.33	24	8.19	9	3.07	73	24.91
Total	89	30.37	100	34.12	104	35.49	293	100

Table 4 illustrates distribution of subjects (males and females) according to body mass index classification (healthy weight, overweight and obese). Total number of subjects who were healthy weight was 95 (32.42%), out of which 48 (37.20%) males and 47 (28.65%) females. Total number of subjects who were overweight was 116 (39.59%), out of which 5 (39.53%) males and 65 (39.63%) females. For obese subjects, it was 82 (27.98%), out of which 30 (23.25%) males and 52 (31.70%) females.

Table 4. Distribution of subjects in accordance to gender and body mass index status.

Body Mass Index kg/m2	**Gender**					
	Males		**Females**		**Total**	
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**
Healthy weight 19- 24.9 kg/m2	48	37.20	47	28.65	95	32.42
Overweight 25-30 kg/m2	51	39.53	65	39.63	116	39.59
Obese > 30 kg/m2	30	23.25	52	31.70	82	27.98
Total	129	44.02	164	55.97	293	100

Table 5 shows the total means and standard deviations of vitamin D levels in males and females. Subjects were classified according to vitamin D levels into deficient (25(OH) D < 20 ng/mL), insufficient (25(OH) D = 20–30 ng/mL) and sufficient (25(OH)D ≥ 30 ng/mL). Total mean and standard deviation of vitamin D deficiency was 12.64± 3.81 (13.93±3.46 and 11.32± 4.16 in males and females, respectively). Total mean and standard deviation of vitamin D insufficiency was 23.61± 2.60 (23.63± 2.44 and 23.61± 2.73 in males and females, respectively), and vitamin D adequacy was 34.18± 3.60 (35.58± 5.05 and 32.79± 2.18 in males and females, respectively).

Table 5. Means and standard deviations of vitamin D levels in males and females.

Gender	**Vitamin D levels ng/ dl**		
	Deficiency < 20 ng/ dl 12.64±3.81 N= 163	**Insufficiency (20-30) ng/ dl** 23.61± 2.60 N= 57	**Adequacy ≥30ng/ dl** 34.18± 3.60 N= 73
Males	13.93 ±3.46	23.63 ± 2.44	35.58± 5.05
Females	11.32± 4.16	23.61 ± 2.73	32.79± 2.18
P. value	< 0.05	0.95	< 0.05

The data are expressed as means and standard deviations. The results were analyzed using SPSS software package version 25 to apply one way ANOVA test to find out the statistical significance between variables. All results were considered significant at p value <0.05.

Table 6 shows means and standard deviations of vitamin D levels in males and females in relation to age groups. Means and standard deviations of vitamin D levels in ages between 20-30 years were 26.58± 12.65 and 16.80±10.31

in males and females, respectively and it was statistically significant between males and females as P.value < 0.05. Means and standard deviations of vitamin D levels in ages between 31-40 years were 20.37± 8.16 and 18.79± 8.07in males and females, respectively. In this age group there was no asignificant differences in vitamin D levels between males and females as P value = 0.2, and in ages between 41-50 years were 26.48± 10.15and 16.57±9.65 in males and females, respectively and there was a significant difference in vitamin D levels between males and females as P value < 0.05.

Table 6. Means and standard deviations of vitamin D levels in males and females in relation to age groups.

Gender	Vitamin D levels ng/ dl			
	20- 30 years	**31- 40 years**	**41- 50 years**	**P. value**
Males	26.58± 12.65	20.37± 8.16	26.48± 10.15	< 0.05
Females	16.80± 10.31	18.79± 8.07	16.57± 9.65	< 0.05
P.value	< 0.05	0.2	< 0.05	

The data are expressed as means and standard deviations. The results were analyzed using SPSS software package version 25 to apply one way ANOVA test to find out the statistical significance between variables. All results were considered significant at p value <0.05.

Table 7 illustrates means and standard deviations of vitamin D levels in males and females in relation to BMI levels. Subjects are classified into three groups according to body mass index levels (Healthy weight, Overweight and obese). Means and standard deviations of vitamin D levels in healthy weight subjects were 27.68± 9.35 and 23.42± 9.35 in males and females, respectively and there was a significant difference in vitamin D levels between males and females as P value < 0.05. Means and standard deviations of vitamin D levels in overweight subjects were 22.05± 9.88 and 17.55± 9.10 in males and females, respectively and there was a significant difference in vitamin D levels between males and females as P value < 0.05, and in obese subjects were 19.22± 11.48 and 11.94±8.58 in males and females, respectively and there was a significant difference in vitamin D levels between males and females as P value < 0.05.

Table 7. Means and standard deviations of vitamin D levels in males and females in relation to BMI levels.

Vitamin D levels	Body Mass Indexkg/m2		
	Healthy weight 19- 24.9 kg/m2	**Overweight 25-30 kg/m2**	**Obese > 30 kg/m2**
Males	27.68± 9.35	22.05±9.88	19.22± 11.48
Females	23.42±9.35	17.55± 9.10	11.94± 8.58
P.value	< 0.05	< 0.05	< 0.05

The data are expressed as means and standard deviations. The results were analyzed using SPSS software package version 25 to apply one way ANOVA test to find out the statistical significance between variables. All results were considered significant at p value <0.05.

DISCUSSION

Tripoli is a sunny city located in western Libya along the Mediterranean coast (32.5231° N, 13.1115° E). In the present study 293 participants (129 males and 164 females) were included. The prevalence of vitamin D deficiency was 55.63%, out of which 25.58% in males and 79.26% in females, while 19.45% of participants had vitamin D insufficiency (23.25% in males and 16.46% in females), and 24.91% of participants had vitamin D Adequacy (51.16% in males and 4.26% in females).

The results were in line with several studies conducted in western, eastern, southern and central Libya, a study in Tripoli identified 61% of nursing mothers had 25(OH)D <30 nmol/l [17], another study conducted among Libyan medical students of Tripoli university which revealed the prevalence of vitamin D deficiency among the students which was 74% (58.7% in males and 83.8% in females), while 21% had vitamin D insufficiency (28% in males and 16.12% in females) [19]. Another study in Tripoli indicated that the prevalence of vitamin D deficiency was more in females than males [20]. Moreover, a study conducted in Alejelat city which reported 64.99% of participants had vitamin D deficiency [21]. A study conducted in Misurata city, western Libya revealed that about 80.0% of participants had insufficient vitamin D levels and women were more susceptible to vitamin D deficiency which counted for 61.6% [**18**]. A study in eastern Libya, Benghazi city showed 76.1% of participants had vitamin D deficiency, 15.2% insufficiency [**16**], and other study demonstrated that 75% of females had 25(OH) D <50 nmol/l

[16].On the other hand, a study in Tobruk showed low prevalence of vitamin D deficiency which counted for39.3% in females and 18% in males and most deficiency lied in the age group 30-35 years [22], while other study in Tobruk revealed 52.1% of population had vitamin D deficiency [23], and a study in central Libya, Bani waled and Sirt cities demonstrated 60% of total population had vitamin D deficiency [24]. In addition, a study conducted in southwest Libya which reported that 58.10% of type II diabetic patients had vitamin D deficiency (Out of which 24.24%in males and 85.36% in females [25]. Other studies conducted in Saudi Arabia which reported high rates of vitamin D deficiency [12, 13]. Furthermore, the study was in agreement with several studies conducted in western countries (Ireland, United Kingdom and Canada) which showed the prevalence of vitamin D deficiency ranged from 10-55.5% [26, 27 and 28].

Vitamin D deficiency is a worldwide concern and is not confined to specific geographical locations and can be occurred due to many factors [29]. The current study highlighted some contributing factors which may lead to vitamin D deficiency including age, lifestyle, sun exposure, physical activity, cultural beliefs and obesity which all seem to be major contributing factors to the high prevalence of vitamin D deficiency. The study reported that vitamin D levels in females were much lower as compared to men and were statistically significant. The results were in agreement with several studies which all revealed higher prevalence of vitamin D deficiency in females than those of men [30, 31 and 32].

In the current study, the high prevalence of vitamin D deficiency among females may attributed to social behaviors due to religious reasons, women must cover all the body with cloths and wear a hijab which counted for 96.95% of females in this study. Vitamin D levels were strongly correlated with the area of skin exposed and duration of sunlight exposure in this study as shown similarly by other studies [33, 34]. Sun exposure of skin areas of face and hands may partially provide vitamin D, but may not be sufficient to prevent vitamin D deficiency [16], especially considering the short duration of sun exposure demonstrated in this study. Clothes are main blockers to sun exposure which have adverse effects on vitamin D status by disrupting vitamin D synthesis [35, 36]. Moreover, 68.25% of subjects had tendency avoiding sunlight exposure and had less than 15 minutes sunlight exposure (out of which 51.19% of females and 17.06% of men). Several studies demonstrated that clothing culture (veiling) and tendency of avoiding sunlight exposure are significant contributors to vitamin D deficiency [16, 37, 38, 39 and 40]. Furthermore, 79.26% of females involved in indoor works and spent less time outdoors which was in contrast to men which counted for 3.10%. The findings were consistent with other studies [35, 36]. Work pattern has a major influence on duration of sunlight exposure and as a consequence influencing vitamin D status [41].

Additionally, 27.30% of subjects had darker skin which may contributes to vitamin D deficiency. Skin color can affect the production of vitamin D through exposing to sunlight. The absorption of sunlight is reduced by melanin pigment of darker skin, Therefore, people with darker skin show lower levels of vitamin D [42, 43].

In the present study, 67.57% of subjects had unhealthy weight (out of which 39.59% overweight and 27.98% obese). Unhealthy weight was more prevalence in females than males. In males, 62.79% had unhealthy weight (out of which 39.53% overweight and 23.25% obese). In females, 71.34% had unhealthy weight (out of which 39.63% overweight and 31.70% obese). The results were in line with other studies conducted in Iraq, Egypt and Libya [18, 44, 45 and 46]. Furthermore, the study demonstrated the adverse effects of obesity on the levels of vitamin D which were significantly different when compared to vitamin D levels among healthy individuals.

Alteration in vitamin D metabolism in obese individuals can be the main cause of vitamin D deficiency among obese individuals [47, 48, and 49]. In obesity, storing vitamin D in adipose tissues makes it unavailable which results in depletion of calcitriol and rise in parathyroid hormone (PTH). This in turns increases intracellular calcium in adipocytes stimulating lipogenesis [50].Adipose tissue is a depot of vitamin D and is difficult to be released into the circulation, which explains the reason of lower vitamin D levels in obese individuals[51, 52].Moreover, the adverse effect of obesity could be due to unhealthier lifestyle, characterized by less physical activity and less sun exposure as demonstrated in this study which revealed that 88.23% of unhealthy weight subjects had less physical activity and had a tendency avoiding sunlight exposure and therefore, leading to lower vitamin D levels and worse clinical outcomes [53].

CONCLUSION

It is concluded that high prevalence of vitamin D deficiency in Tripoli population and was higher in females than males especially among ages 41- 50 years. Obesity was considered as contributing factor to low level of vitamin D. Much effort has to be done for educating and raising the awareness among the community on the necessity and the importance of vitamin D and how to prevent vitamin D deficiency. Adapting proper lifestyle focused on maintaining health weight, sufficient sunlight exposure and increasing dietary intake of vitamin D can reduce the burden of vitamin D deficiency.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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تقييم حالة فيتامين د بين السكان البالغين في منطقة طرابلس، ليبيا

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المستخلص

الخلفية والأهداف. نقص فيتامين د هي مشكلة وبائية عامة نتيجة لإنتشار نقصه في كل أنحاء العالم. تم تسجيل معدلات انتشار عالية لعوز فيتامين د في المناطق المشمسة في كل أنحاء العالم ومن ضمنها ليبيا. هدفت الدراسة إلي تقييم مدي انتشار عوز فيتامين د في الناس البالغين بمنطقة طرابلس, بالإضافة إلي تقييم بعض عوامل الخطر والتي تشمل العمر والجنس والسمنة. **طرق الدراسة**. دراسة مقطعية تم عملها علي 293 شخص (129 من الرجال و 164 من النساء) تراوحت أعمارهم بين 20-50 سنة بمنطقة طرابلس, غرب ليبيا. تم قياس فيتامين د بيوكيميائيا بواسطة الطريقة الإنزيمية المناعية, باللإضافة إلي قياس مؤشر كتلة الجسم لكل المستهدفين للدراسة (الوزن بالكيلوجرام مقسوما علي مربع الطول). **النتائج**. معدل انتشار عوز فيتامين د كان 55.63%, حيث كان منهم 25.58% من الرجال و 79.26% من النساء, بينما 19.45% من الأشخاص كان لديهم فيتامين د غير كافي (23.25% منهم من الرجال و 16.46% من النساء). بالإضافة إلي ذالك 24.91% من الأشخاص كان لديهم مستوي كافي من فيتامين د (51.16% من الرجال و 4.26% من النساء). أعلي معدل انتشار لعوز فيتامين د كان في الفئة العمرية بين 41-50 سنة. متوسط تركيز فيتامين د كان 13.93 ± 3.46 و 11.31 ± 4.16 في الرجال والنساء علي التوالي, وكان هناك اختلاف معنوي. بالإضافة إلي ذالك كان هناك اختلاف معنوي بين المجموعات الثلاثة (أشخاص لديهم وزن صحي, زيادة في الوزن, سمنة). **الخاتمة**. معدل انتشار عالي لعوز فيتامين د بمنطقة طرابلس, غرب ليبيا, وكان معدل الإنتشار في النساء أكثرمنه في الرجال وخاصة في الفئة العمرية مابين 41-50 سنة. السمنة لها تأثير سلبي علي مستويات فيتامين د والتي تساهم في النقص الشديد لفيتامين د. تبني نظام صحي يعتمد علي المحافظة علي الوزن المثالي وتعرض كافي لأشعة الشمس مع تناول الأغدية الغنية بفيتامين د يمكن أن يؤدي إلي نقص معدل انتشار عوز فيتامين د.

الكلمات المفتاحية. فيتامين د, عوز, غير كافي, كافي, مؤشر كتلة الجسم.