East African Scholars Journal of Medical Sciences
Abbreviated Key Title: East African Scholars J Med Sci
ISSN 2617-4421 (Print) | ISSN 2617-7188 (Online) |
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-2 | Issue-11| Nov -2019 | DOI:10.36349/EASMS.2019.v02i11.055

Research Article

Evaluation of Vitamin D Status among Populations in Alejelat, Libya

Afaf Amer Abumhdi[1*] Azab Elsayed Azab[2*]and Mohamed Omar Albasha[3]

[1]Department of Chemistry, Faculty of Science, Sabratha University, Libya
[2]Department of Physiology, Faculty of Medicine, Sabratha University, Libya
[3]Department of Zoology, Alejelat Faculty of Science, Zawia University, Libya

*Corresponding Author
Azab Elsayed Azab
Email:- azabelsaied@yahoo.com

Abstract: **Background:** Vitamin D deficiency has become a major public health problem as it is prevalent in all age groups and ethnicities. The higher rates of hypovitaminosis D in the sunniest areas of the world, including the Middle East, Asian, and North Africa countries, such as Libya. Rickets and osteomalacia still occur in this sunny region. Hypovitaminosis D prevails, with rates varying 30–90%. **Objectives:** The aim of our study was to evaluate the vitamin D status among populations in Alejelat region in Western Libya. **Methods:** An observational study was conducted among 377 subjects (141 males & 236 Females) in Alejelat region in Western Libya, over a period of six months from first March 2019 to 30th August 2019. The subjects participating in the study were requested to complete a questionnaire that covered socio-demographic data. Serum 25-hydroxyvitamin D (25(OH) D) level was measured using an enzyme immunoassay method. The associations of the levels of 25(OH)D_3 with gender, and age groups were assessed throughout using the Chi-square test. **Results:** Out of 377 subjects; 236 subjects (62.6%) were females, and 141 subjects (37.4%) were males. The higher percentage of subjects were 56.78% in females and 31.21% in males in those aged (21-40) years. The prevalence of vitamin D deficiency was 57.45% in males and 69.49% in females. Overall, the estimated prevalence of severe vitamin D deficiency (< 10 ng/ml) was 39.26%, Moderate vitamin D deficiency (10-20 ng/ml) was 25.73%, insufficiency (21-29 ng/ml) was 17.77% and the proportion of the sample population with adequacy of vitamin D concentrations (≥30 ng/ml) was 17.24%. The higher prevalence of vitamin D deficiency were 37.59% moderate vitamin D deficiency in male subjects and 39.26% severe vitamin D deficiency in female subjects. According to age groups, the higher prevalence of severe vitamin D deficiency was 10.1%, moderate vitamin D deficiency was 23.6%, insufficiency was 7.4%, and the adequacy of vitamin D concentrations was 6.1% in age groups (21-40). **Conclusion:** From the results, we found that prevalence of vitamin D deficiency was very high among Populations in Alejelat. To prevent vitamin D deficiency, the recommended intake of food sources rich in vitamin D and expose skin to the sun light for enough time to increase vitamin D production endogenously.

Keywords: 25-hydroxyvitamin D, Vitamin D Levels, Vitamin D deficiency, Western Libya, Alejelat.

1. INTRODUCTION

In recent years, there has been an increased understanding of the role that vitamin D plays in regulation of cell growth, immunity, and cell metabolism (Al Emadi, S., & Hammoudeh, M. 2013). Also, vitamin D has many functions in humans including calcium and phosphate homeostasis (Heaney, R. P. *et al.*, 2013; Edwards, M. H. *et al.*, 2014). Vitamin D receptors can be found in most tissues and cells in the body (Al Emadi, S., & Hammoudeh, M. 2013). Vitamin D is mainly synthesized in the skin (Wacker, M., & Holick, M. F. 2013; Nair, R., & Maseeh, A. 2012; Morrissey, H. *et al.*, 2019) but the process is influenced by environmental and lifestyle factors. People with dark skin are more susceptible to Vitamin D deficiency probably because melanin pigment absorbs Ultra Violet B (Nair, R., & Maseeh, A. 2012; Morrissey, H. *et al.*, 2019). Sun screen applications and minimum outdoor activities are human behaviours that, reduce vitamin D production endogenously. Further, skin vitamin D production varies according to the time of the day, season of the year and zenith angle of the sun (Wacker, M., & Holick, M. F. 2013; Morrissey, H. *et al.*, 2019). Exposing face and arms to sunlight for 25 minutes, 3 times a week at 9 a.m. helps maintaining adequate vitamin D level

Quick Response Code

Journal homepage:
http://www.easpublisher.com/easjms/

Article History
Received: 30.10.2019
Accepted: 12.11.2019
Published: 25.11.2019

(Morrissey, H. *et al.,* 2019; Nimitphong, H., & Holick, M. F. 2013). Once vitamin D absorbed from the gut or produced in the skin, it is then hydroxylated in the liver into 25-hydroxyvitamin D (25(OH) D) and then in the kidney and in extrarenal tissues to 1,25-dihydroxyvitamin D (1,25(OH)2D) and 24,25-dihydroxyvitamin D (24,25(OH)2D). Thereafter, the active metabolite can enter cells and bind to either the vitamin D-receptor or to a responsive gene, such as that of calcium binding protein, and thus assist in calcium absorption (Heaney, R. P. *et al.,* 2003; Edwards, M. H. *et al.,* 2014). Vitamin D also regulates parathyroid hormone levels which in turn reduces bone loss (Edwards, M. H. eta l., 2014; Steingrimsdottir, L. *et al.,* 2005).

Rickets and osteomalacia still occur in this sunny region. Hypovitaminosis D prevails, with rates varying 30–90%, considering a desirable serum 25 hydroxy-vitamin D [25(OH)D] of 20 ng/ml. Advancing age, female gender, multiparity, clothing style, season, socio-economic status and urban living are recognized predictors of hypovitaminosis D in adults. Prolonged breastfeeding without vitamin D supplementation and low dietary calcium intake are the recognized risk factors for rickets and hypovitaminosis D in children. Associations with pain score and disease activity in rheumatologic disorders, viral load and interleukins in hepatitis C, BMI, lipids and insulin sensitivity, blood pressure, heart failure and mortality are described (Bassil, D. *et al.,* 2013).

Vitamin D deficiency has become a major public health problem as it is prevalent in all age groups and ethnicities (Morrissey, H. *et al.,* 2019; Palacios, C., & Gonzalez, L. 2014). It is linked with a multitude of co-morbidities (Morrissey, H. *et al.,* 2019). About one billion people in the world suffer from vitamin D deficiency or insufficiency. The consequences of vitamin D deficiency include poor bone development and ill health as well as increased risk of many common and serious diseases, including some common cancers, cardiovascular diseases, type one diabetes, autoimmune diseases, high blood pressure, and age-related cognitive decline, Parkinson's disease, multiple sclerosis and arthritis (Thomas, M. K. *et al.,* 1998; Holick M. F. 2007; Autier, P. *et al.,* 2014; Omar, M. *et al.,* 2017). The high prevalence of hypovitaminosis D, despite the availability of sunlight throughout the year has raised many questions (Morrissey, H. *et al.,* 2019). In Libya, rickets is almost exclusively diagnosed in children less than 2 years of age, and authors are not aware of significant long term skeletal deformities (Markestad, T., & Elzouki, A. Y. (1991). In Libya and other Arab countries pregnant women, and consequently their newborn infants, are commonly severely vitamin D deficient (Markestad, T., & Elzouki, A. Y. 1991; Markestad, T. *et al.,* 1984; Serenius, F. *et al.,* 1984). Benghazi city is sunny most of the year; there is a lack of research on Vitamin D status in Libya (Omar, M. *et al.,* 2017). The Middle East and North Africa region registers some of the highest rates of hypovitaminosis D Worldwide (Bassil, D. *et al.,* 2013). A recent reports have shown that higher rates of hypovitaminosis D in the sunniest areas of the world, including the Middle East, Asian, and North Africa countries, such as Libya, Qatar, Saudi Arabia, United Arab Emirates, Iran Turkey, and India (Omar, M. *et al.,* 2017; Meddeb, N. et6 al., 2005; Hovsepian, S. *et al.,* 2011; Naeem, Z. *et al.,* 2011; Badawi, A. *et al.,* 2012; Alsuwadia, A. O. *et al.,* 2013; Botros, R. M. *et al.,* 2015).

It is important for a country to know the determinants of vitamin D level of the population. The information can be used in designing health promotion programs to optimize vitamin D level at population level. This will prevent indiscriminative use of vitamin D supplementation and thereby reduce the additional cost that patients have to bear (Morrissey, H. et al., 2019).

Subasinghe *et al., (*2019*)* investigated that the prevalence of vitamin D deficiency in 132 premenopausal women between 20-40 years in Sri Lanka. Eight subjects (6.1%) were Vit-D deficient while 68 (51.5%) had Vit-D insufficiency. No difference in vit-D status according to age (20-30 vs 31-40 years). Hypovitaminosis D is prevalent among community dwelling healthy middle-aged women in Sri Lanka.

Studies on vitamin D in western Libya population are scarce. So, the aim of the present study was to evaluate the vitamin D status among populations in Alejelat region in Western Libya.

2. SUBJECTS AND METHODS

An observational study was conducted among 377 subjects (141 males & 236 Females) in Alejelat region in Western Libya, over a period of six months from first March 2019 to 30th August 2019. The subjects participating in the study were requested to complete a questionnaire that covered socio-demographic data. Serum 25-hydroxyvitamin D (25(OH) D) level was measured using an enzyme immunoassay method. Exclusion criteria included the use of medications known to affect bone metabolism, such as seizure drugs phenobarbital, anti-tuberculosis drugs, cholesterol-lowering statin drugs, thiazide diuretics, anti retroviral drugs, and glucocorticoids. All participants provided written informed consent. The University Ethics Committee approved the protocol. Severe vitamin D deficiency was defined as 25-OHD values of <10 ng/ml (Ginde, A. A. *et al.,* 2009), moderate Vitamin D deficiency was defined as 25-OHD values of 10-20 ng/ml, insufficiency at 21-29 ng/l; and adequate serum 25-OHD level at ≥30 ng/ml (Holick, M. F. *et al.,* 2011).

STATISTICAL ANALYSIS

Data were analysed using SPSS version 25. The associations of the levels of 25(OH)D_3 with gender, and age groups were assessed throughout using the Chi-square test.

RESULTS

Out of 377 subjects; 236 subjects (62.6%) were females, and 141 subjects (37.4%) were males. Overall, by age groups were 64 subjects (16.98%) in those aged (1-20) years, 178 subjects (47.21%) in those aged (21-40) years, 81 subjects (21.49%) in those aged (41-60) years, 54 subjects (14.32%) in those aged (61-80) years. The higher numbers of subjects were 134 subjects (56.78%) in females and 44 subjects (31.21%) in males in those aged (21-40) years (Table.1 & Figure. 1).

Table.1: Distribution of cases according to gender and age groups

Gender Age groups (Years)	Males		Females		Total	
	Frequency	%	Frequency	%	Frequency	%
1-20	31	21.99	33	13.98	64	16.98
21-40	44	31.21	134	56.78	178	47.21
41-60	35	24.82	46	19.49	81	21.49
61-80	31	21.99	23	9.75	54	14.32
Total	141	100	236	100	377	100

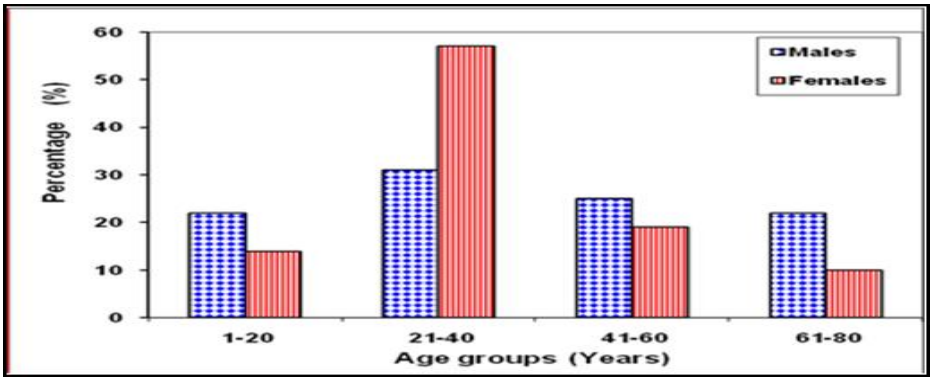

Figure.1: Distribution of subjects according to gender and age groups

The prevalence of vitamin D deficiency was 57.45% in males and 69.49% in females. Overall, the estimated prevalence of severe vitamin D deficiency (< 10 ng/ml) was 39.26%, Moderate vitamin D deficiency (10-20 ng/ml) was 25.73%, insufficiency (21-29 ng/ml) was 17.77% and the proportion of the sample population with adequacy of vitamin D concentrations (≥30 ng/ml) was 17.24%. The estimated prevalence of vitamin D deficiency in male subjects: severe vitamin D deficiency (< 10 ng/ml) was 19.86%, Moderate vitamin D deficiency (10-20 ng/ml) was 37.59%, insufficiency (21-29 ng/ml) was 23.40% and the proportion of the sample population with adequacy of vitamin D concentrations (≥30 ng/ml) was 19.15%. The estimated prevalence of vitamin D deficiency in female subjects: severe vitamin D deficiency (<10 ng/ml) was 39.26%, Moderate vitamin D deficiency (10-20 ng/ml) was 25.73%, insufficiency (21-29 ng/ml) was 17.77% and the proportion of the sample population with adequacy of vitamin D concentrations (≥30 ng/ml) was 17.24% as shown in Table (2) and Figure (2).

Table.2: Distribution of subjects according to gender and Vitamin D Levels

Gender Vitamin D Levels	Males		Females		Total	
	Frequency	%	Frequency	%	Frequency	%
Severe Deficiency (< 10)	28	19.86	120	50.85	148	39.26
Moderate Deficiency (10-20)	53	37.59	44	18.64	97	25.73
Insufficiency (21-29)	33	23.40	34	14.41	67	17.77
Adequacy ≥30	27	19.15	38	16.10	65	17.24
Total	141	100	236	100	377	100

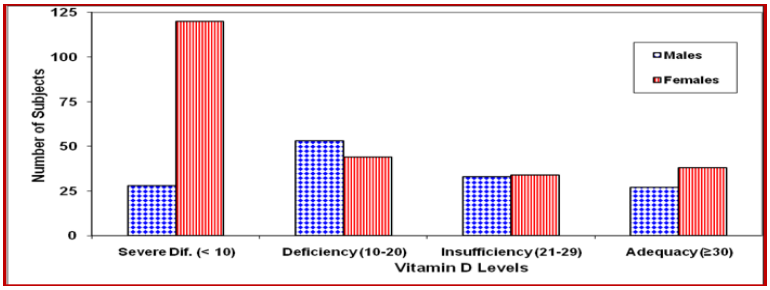

Figure.2: Distribution of subjects according to gender and Vitamin D Levels

Data in table (3) and figure (3) shown the distribution of subjects according to age groups and vitamin D levels. According to age groups, the estimated prevalence of severe vitamin D deficiency (< 10 ng/ml) was 19, 38, 30, and 14 subjects in age groups, (1-20), (21-40), (41-60), and (61-80) respectively. The estimated prevalence of moderate vitamin D deficiency (11-20 ng/ml) was 18, 89, 15, and 16 subjects in age groups, (1-20), (21-40), (41-60), and (61-80) respectively. The estimated prevalence of insufficiency (21-29 ng/ml) was 9, 28, 20, and 12 subjects in age groups, (1-20), (21-40), (41-60), and (61-80) respectively, and the proportion of the sample population with adequacy of vitamin D concentrations (≥30 ng/ml) was 18, 23, 16, and 12 subjects in age groups, (1-20), (21-40), (41-60), and (61-80) respectively.

Table.3: Distribution of subjects according to age groups and vitamin D levels

Vitamin D Levels / Age Groups	Severe Deficiency (10>) ng/ml		Moderate Deficiency (11-20) ng/ml		Insufficiency (21-29) ng/ml		Adequacy (≥30) ng/ml	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
1-20	19	5.0	18	4.8	9	2.4	18	4.8
21-40	38	10.1	89	23.6	28	7.4	23	6.1
41-60	30	8.0	15	4.0	20	5.3	16	4.2
61-80	14	3.7	16	4.2	12	3.2	12	3.2
Total	101	26.8	138	36.6	69	18.3	69	18.3

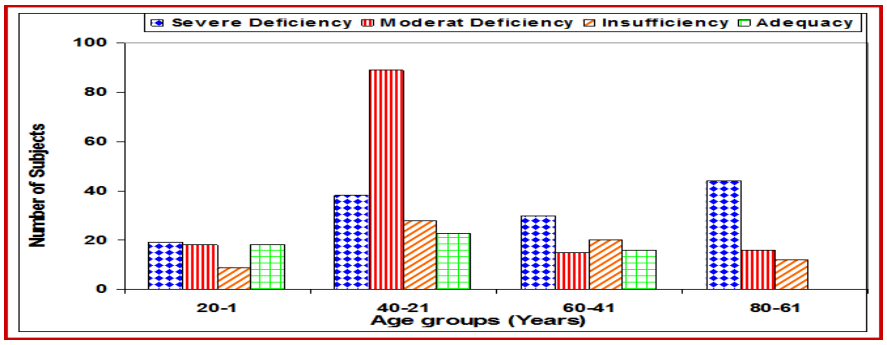

Figure.3: Distribution of subjects according to age groups and vitamin D levels

The distribution of male subjects according to age groups and vitamin D levels are shown in table(4) and figure (4). According to age groups, the estimated prevalence of severe vitamin D deficiency (< 10 ng/ml) was 2, 9, 9, and 8 subjects in age groups, (1-20), (21-40), (41-60), and (61-80) respectively. The estimated prevalence of moderate vitamin D deficiency (11-20 ng/ml) was 12, 15, 10, and 11 subjects in age groups, (1-20), (21-40), (41-60), and (61-80) subjects in age groups, (1-20), (21-40), (41-60), and (61-80) respectively, and the proportion of the sample population with adequacy of vitamin D concentrations (≥30 ng/ml) was 12, 6, 6, and 6 subjects in age groups, (1-20), (21-40), (41-60), and (61-80) respectively.

Table.4: Distribution of the male subjects according to age groups and vitamin D levels

Vitamin D Levels	Severe Deficiency (10>)ng/ml		Moderate Deficiency (11-20) ng/ml		Insufficiency (21-29) ng/ml		Adequacy (30(≥ng/ml	
Age Groups	Frequency	%	Frequency	%	Frequency	%	Frequency	%
1-20	2	0.5	12	3.2	5	1.3	12	3.2
21-40	9	2.4	15	4.0	14	3.7	6	1.6
41-60	9	2.4	10	2.7	10	2.7	6	1.6
61-80	8	2.1	11	2.9	6	1.6	6	1.6
Total	28	7.4	48	12.7	35	9.3	30	8.0

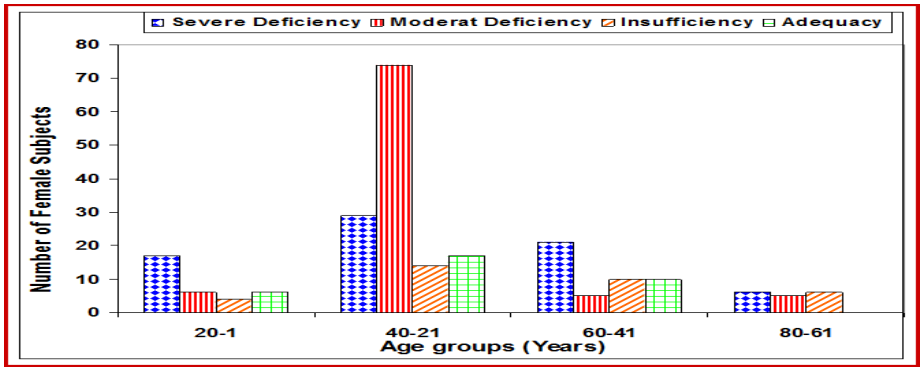

Figure.4: Distribution of female subjects according to age groups and vitamin D levels

The distribution of female subjects according to age groups and vitamin D levels are shown in table (5) and figure (5). According to age groups, the estimated prevalence of severe vitamin D deficiency (< 10 ng/ml) was 17, 29, 21, and 6 subjects in age groups, (1-20), (21-40), (41-60), and (61-80) respectively. The estimated prevalence of moderate vitamin D deficiency (11-20 ng/ml) was 6, 74, 5, and 5 subjects in age groups, (1-20), (21-40), (41-60), and (61-80) respectively. The estimated prevalence of insufficiency (21-29 ng/ml) was 4, 14, 10, and 6 subjects in age groups, (1-20), (21-40), (41-60), and (61-80) respectively, and the proportion of the sample population with adequacy of vitamin D concentrations (≥30 ng/ml) was 6, 17, 10, and 6subjects in age groups, (1-20), (21-40), (41-60), and (61-80) respectively (Table .5 & Figure.5).

Table.5: Distribution of the female subjects according to age groups and vitamin D levels

Vitamin D Levels	Severe Deficiency		Moderate Deficiency		Insufficiency		Adequacy	
	(10>)ng/ml		(11-20) ng/ml		(21-29) ng/ml		(30(≥ng/ml	
Age Groups	Frequency	%	Frequency	%	Frequency	%	Frequency	%
1-20	17	4.5	6	1.6	4	1.1	6	1.6
21-40	29	7.7	74	19.6	14	3.7	17	4.5
41-60	21	5.6	5	1.3	10	2.7	10	2.7
61-80	6	1.6	5	1.3	6	1.6	6	1.6
Total	73	19.4	90	23.9	34	9.0	39	10.3

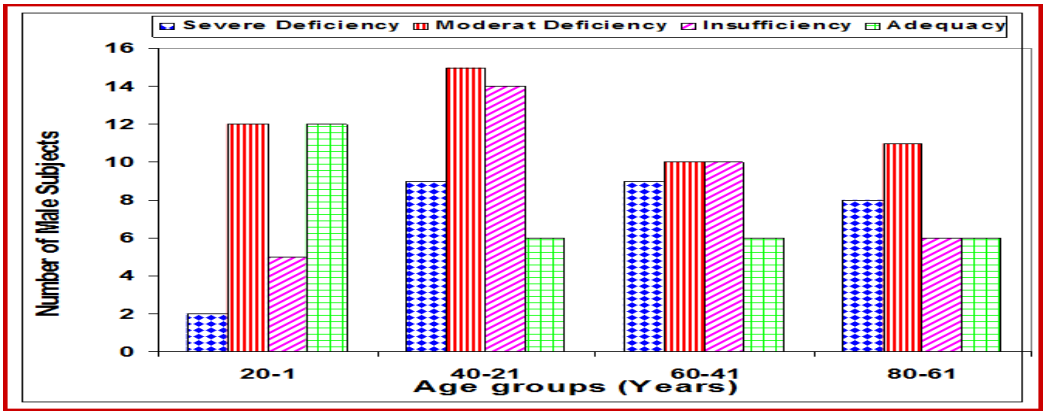

Figure.5: Distribution of male subjects according to age groups and vitamin D levels

4. DISCUSSION

Alajelat is a sunny city situated in northwestern Libya along the Mediterranean coast. The vitamin D deficiency has been defined as a serum 25 (OH) D3 level less than 20 ng/mL and the 25(OH)D3 level of 21 ng/mL to 29 ng/mL is considered insufficiency for vitamin D (Ginde, A. A. *et al*., 2009). The prevalence of vitamin D deficiency was 64.99% among the population in Alajelat region and an even higher prevalence among females than males. The high prevalence of vitamin D deficiency seen among study subjects is concordant with previous studies done in African-Americans and Hispanics (69.2%) (Forrest, K. Y., & Stuhldreher, W. L. 2011; Wu, Y. *et al.*, 2017) and in Sri Lanka (57.2%) (Rodrigo, M. *et al.*, 2013). More than 50% of the world's population is at risk of hypovitaminosis D in Mexico, Europe, Asia, India, and Africa (Holick M. F. 2007; Looker, A. C. *et al.*, 2011; Hossein-nezhad, A., & Holick, M. F. 2012).

In children and adolescents, the proportion of subjects with a 25(OH)D level below 15–20 ng/ml ranged between 12%–62% in children in studies from Algeria, Iran, Bahrain, Egypt, Iran, Jordan, and Lebanon (Hoteit, M. *et al.,* 2014), and 54-90% in pregnant women. In adults, it ranged between 44 and 96% (Bassil, D. *et al.,* 2013; Chakhtoura, M. *et al.,* 2018). The highest proportions were reported in studies from KSA and UAE reaching proportions of 96% and 99% for this cut off, respectively (Hoteit, M. *et al.,* 2014). The rates of vitamin D deficiency reported in this study are markedly higher than in many western countries. In Italy, Austria, North Europe (Finland, Denmark, Poland, and Ireland), United Kingdom, and Canada prevalence of vitamin D deficiency range from 10-55.5% (Ashwell, M. *et al.,* 2010; Madsen, K. H. *et al.,* 2014; Austrian Nutrition Report. 2012; Canadian National Institute of Health. 2016; Russ, T. C. *et al.,* 2016), but the prevalence of vitamin D deficiency in Alajelat is lower than in Benghazi in the east of Libya, which was 76.1% (Omar, M. *et al.,* 2017). Also, Similar the prevalence of vitamin D deficiency was higher in other countries such as Egypt (Botros, R. M. *et al.,* 2015), Tunisia(Hovsepian, S. *et al.,* 2011), Qatar (Badawi, A. *et al.,* 2012), Saudi Arabia (Naeem, Z. *et al.,* 2011), and Iran (Hovsepian, S. *et al.,* 2011). Advancing age, female gender, multiparity, clothing style, season, socio-economic status and urban living are recognized predictors of hypovitaminosis D in adults (Bassil, D. *et al.,* 2013). Consistent predictors of low 25(OH)D levels across the lifecycle included increasing age, female gender, high weight or body mass index(BMI), low physical activity, low intake of calcium or vitamin D supplements, concealed clothing, low sun exposure duration, winter season, lower education or socio-economic status, and urban residence (Hoteit, M. *et al.,* 2014; Chakhtoura, M. *et al.,* 2018; Fouda, M. A. *et al.,* 2017; Kaddam, I. M. *et al.,* 2017; Naseh, A. *et al.,* 2018). Added to that is smoking status in adults and maternal weight at delivery (Hoteit, M. *et al.,* 2014; Chakhtoura, *et al.,* 2018). Also, genetic factors, namely polymorphisms in key genes of the vitamin D pathway, mod-ulate vitamin D status in western populations and possibly the MiddleEast (Chakhtoura, M. *et al.,* 2018; Arabi, A. *et al.,* 2017). In addition, prolonged breastfeeding without vitamin D supplementation and low dietary calcium intake are the recognized risk factors for rickets and hypovitaminosis D in children (Bassil, D. *et al.,* 2013).

The high prevalence of vitamin D deficiency was 33.69% in age group (21-40), this result is not away from what was obtained by Rodrigo *et al., (*2013*)* who found that the prevalence of vitamin D deficiency in age group (20-40)was 40.5% of subjects. In a London antenatal population, a vitamin D deficiency was found in 47% of Indian Asian women, 64% of Middle Eastern women, 58% of black women and 13% of Caucasian women (Yu, C. K. H. *et al.,* 2009).

In the present study, the prevalence of severe vitamin D deficiency in females was 19.4% which is concordant with the study of Nicolaidou *et al.,(2006)* who found that 20% of women presented vitamin D deficiency, as defined by serum levels of 25(OH)D <10 ng/mL.

6. CONCLUSION

It can be concluded that Vitamin D deficiency is a common health issue in Alejelat population in Western Libya. The higher prevalence of vitamin D deficiency was more in females than males especially in severe vitamin D deficiency which was 50.85% in females and 19.86% in males. The higher prevalence of vitamin D deficiency was in age groups (21-40) in both gender. To prevent vitamin D deficiency, the recommended intake of food sources rich in vitamin D and expose skin to the sun light for enough time to increase vitamin D production endogenously. Preventive health care is supposed to be more effective in this area. Hence, it is always important to understand the background characteristics of women and their children to increase the awareness on preventive health care practices. Improving women education and health education about balanced animal and plant food consumption are recommended strategies to reduce the burden of vitamin D deficiency. Government should implement health program in conducting vitamin D estimation for all age in a regular basis and use these information's in designing health promotion programs to optimize vitamin D level at population level. This study should be replicated in more settings to see if the findings are similar.

REFERENCES

1. Al Emadi, S., & Hammoudeh, M. (2013). Vitamin D study in pregnant women and their babies. *Qatar medical journal*, *2013*(1), 7.
2. Heaney, R. P., Dowell, M. S., Hale, C. A., & Bendich, A. (2003). Calcium absorption varies within the reference range for serum 25-hydroxyvitamin D. *Journal of the American college of nutrition*, *22*(2), 142-146.
3. Edwards, M. H., Cole, Z. A., Harvey, N. C., & Cooper, C. (2014). The global epidemiology of vitamin D status. *J Aging Res Clin Prac*, *3*(3), 148-58.
4. Wacker, M., & Holick, M. F. (2013). Sunlight and Vitamin D: A global perspective for health. *Dermato-endocrinology*, *5*(1), 51-108.
5. Nair, R., & Maseeh, A. (2012). Vitamin D: The "sunshine" vitamin. *Journal of pharmacology & pharmacotherapeutics*, *3*(2), 118.
6. Morrissey, H., Subasinghe, S., Ball, P. A., Lekamwasam, S., & Waidyaratne, E. (2019). Sunlight exposure and serum vitamin D status among community dwelling healthy women in Sri Lanka.

7. Nimitphong, H., & Holick, M. F. (2013). Vitamin D status and sun exposure in Southeast Asia. *Dermato-endocrinology*, *5*(1), 34-37.
8. Steingrimsdottir, L., Gunnarsson, O., Indridason, O. S., Franzson, L., & Sigurdsson, G. (2005). Relationship between serum parathyroid hormone levels, vitamin D sufficiency, and calcium intake. *Jama*, *294*(18), 2336-2341.
9. Bassil, D., Rahme, M., Hoteit, M., & Fuleihan, G. E. H. (2013). Hypovitaminosis D in the Middle East and North Africa: prevalence, risk factors and impact on outcomes. *Dermato-endocrinology*, *5*(2), 274-298.
10. Palacios, C., & Gonzalez, L. (2014). Is vitamin D deficiency a major global public health problem? *The Journal of steroid biochemistry and molecular biology*, *144*, 138-145.
11. Thomas, M. K., Lloyd-Jones, D. M., Thadhani, R. I., Shaw, A. C., Deraska, D. J., Kitch, B. T., ... & Finkelstein, J. S. (1998). Hypovitaminosis D in medical inpatients. *New England Journal of Medicine*, *338*(12), 777-783.
12. Holick M. F. (2007). Vitamin D deficiency, The New England Journal of Medicine, 357(3), 266–281,
13. Autier, P., Boniol, M., Pizot, C., & Mullie, P. (2014). Vitamin D status and ill health: a systematic review. *The lancet Diabetes & endocrinology*, *2*(1), 76-89.
14. Omar, M., Nouh, F., Younis, M., Younis, M., Nabil, N., Saad, M., & Ali, M. (2017). Vitamin D status and contributing factors in patients attending three polyclinics in Benghazi Libya. *Journal of Advances in Medicine and Medical Research*, 1-13.
15. Markestad, T., & Elzouki, A. Y. (1991). Vitamin D deficiency rickets in northern Europe and Libya. In *Rickets: nestle nutrition Workshop series* (Vol. 21). New York: Raven Press.
16. Markestad, T., Elzouki, A., Legnain, M., Ulstein, M., & Aksnes, L. (1984). Serum concentrations of vitamin D metabolites in maternal and umbilical cord blood of Libyan and Norwegian women. *Human nutrition. Clinical nutrition*, *38*(1), 55-62.
17. Serenius, F., Elidrissy, A. T., & Dandona, P. (1984). Vitamin D nutrition in pregnant women at term and in newly born babies in Saudi Arabia. *Journal of clinical pathology*, *37*(4), 444-447.
18. Meddeb, N., Sahli, H., Chahed, M., Abdelmoula, J., Feki, M., Salah, H., ... & Zouari, B. (2005). Vitamin D deficiency in Tunisia. *Osteoporosis International*, *16*(2), 180-183.
19. Hovsepian, S., Amini, M., Aminorroaya, A., Amini, P., & Iraj, B. (2011). Prevalence of vitamin D deficiency among adult population of Isfahan City, Iran. *Journal of health, population, and nutrition*, *29*(2), 149.
20. Naeem, Z., AlMohaimeed, A., Sharaf, F. K., Ismail, H., Shaukat, F., & Inam, S. B. (2011). Vitamin D status among population of Qassim region, Saudi Arabia. *International journal of health sciences*, *5*(2), 116.
21. Badawi, A., Arora, P., Sadoun, E., Al-Thani, A. A., & Al Thani, M. H. (2012). Prevalence of vitamin D insufficiency in Qatar: a systematic review. *Journal of public health research*, *1*(3), 229.
22. Alsuwadia, A. O., Farag, Y. M., Al Sayyari, A. A., Mousa, D. H., Alhejaili, F. F., Al-Harbi, A. S., ... & Singh, A. K. (2013). Prevalence of vitamin D deficiency in Saudi adults. *Saudi Med J*, *34*(8), 814-818.
23. Botros, R. M., Sabry, I. M., Abdelbaky, R. S., Eid, Y. M., Nasr, M. S., & Hendawy, L. M. (2015). Vitamin D deficiency among healthy Egyptian females. *Endocrinologia y Nutricion*, *62*(7), 314-321.
24. Ginde, A. A., Liu, M. C., & Camargo, C. A. (2009). Demographic differences and trends of vitamin D insufficiency in the US population, 1988-2004. *Archives of internal medicine*, *169*(6), 626-632.
25. Holick, M. F., Binkley, N. C., Bischoff-Ferrari, H. A., Gordon, C. M., Hanley, D. A., Heaney, R. P., ... & Weaver, C. M. (2011). Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. *The Journal of Clinical Endocrinology & Metabolism*, *96*(7), 1911-1930.
26. Forrest, K. Y., & Stuhldreher, W. L. (2011). Prevalence and correlates of vitamin D deficiency in US adults. *Nutrition research*, *31*(1), 48-54.
27. Wu, Y., Sarkissyan, M., Clayton, S., Chlebowski, R., & Vadgama, J. V. (2017). Association of vitamin D3 level with breast cancer risk and prognosis in African-American and Hispanic women. *Cancers*, *9*(10), 144.
28. Rodrigo, M., Hettiarachchi, M., Liyanage, C., & Lekamwasam, S. (2013). Low serum vitamin D among community-dwelling healthy women in Sri Lanka. *Health*, *5*(12), 1997.
29. Looker, A. C., Johnson, C. L., Lacher, D. A., Pfeiffer, C. M., Schleicher, R. L., & Sempos, C. T. (2011). Vitamin D status: United states, 2001–2006. *NCHS data brief*, *59*(59), 1-8.
30. Hossein-nezhad, A., & Holick, M. F. (2012). Optimize dietary intake of vitamin D: an epigenetic perspective. *Current Opinion in Clinical Nutrition & Metabolic Care*, *15*(6), 567-579.
31. Hoteit, M., Al-Shaar, L., Yazbeck, C., Sleiman, M. B., Ghalayini, T., & Fuleihan, G. E. H. (2014). Hypovitaminosis D in a sunny country: time trends, predictors, and implications for practice guidelines. *Metabolism*, *63*(7), 968-978.
32. Chakhtoura, M., Rahme, M., Chamoun, N., & Fuleihan, G. E. H. (2018). Vitamin D in the Middle East and North Africa. *Bone reports*, *8*, 135-146.

33. Ashwell, M., Stone, E. M., Stolte, H., Cashman, K. D., Macdonald, H., Lanham-New, S., ... & Fraser, D. (2010). UK Food Standards Agency Workshop Report: an investigation of the relative contributions of diet and sunlight to vitamin D status. *British Journal of Nutrition*, *104*(4), 603-611.
34. Madsen, K. H., Rasmussen, L. B., Mejborn, H., Andersen, E. W., Mølgaard, C., Nissen, J., ... & Andersen, R. (2014). Vitamin D status and its determinants in children and adults among families in late summer in Denmark. *British Journal of Nutrition*, *112*(5), 776-784.
35. Austrian Nutrition Report. (2012). Österreichischer Ernährungsbericht. Bundesministerium für Gesundheit, Wien.
36. Canadian National Institute of Health. (2016). Strengthening knowledge and understanzding of dietary supplements; Vitamin D Fact Sheet for Health Professionals.
37. Russ, T. C., Murianni, L., Icaza, G., Slachevsky, A., & Starr, J. M. (2016). Geographical variation in dementia mortality in italy, new zealand, and chile: The impact of latitude, Vitamin D, and air pollution. *Dementia and geriatric cognitive disorders*, *42*(1-2), 31-41.
38. Fouda, M. A., Turkestani, I. Z., Almusharraf, S., Al-Ajlan, A., Angkaya-Bagayawa, F. F., Sabico, S., ... & Al-Daghri, N. M. (2017). Extremely high prevalence of maternal and neonatal vitamin D deficiency in the Arab population. *Neonatology*, *112*(3), 225-230.
39. Kaddam, I. M., Al-Shaikh, A. M., Abaalkhail, B. A., Asseri, K. S., Al-Saleh, Y. M., Al-Qarni, A. A., ... & Mukhtar, A. M. (2017). Prevalence of vitamin D deficiency and its associated factors in three regions of Saudi Arabia: A cross-sectional study. *Saudi medical journal*, *38*(4), 381.
40. Naseh, A., Ashrafzadeh, S., & Rassi, S. (2018). Prevalence of vitamin D deficiency in pregnant mothers in Tehran and investigating its association with serum glucose and insulin. *The Journal of Maternal-Fetal & Neonatal Medicine*, *31*(17), 2312-2318.
41. Arabi, A., Khoueiry-Zgheib, N., Awada, Z., Mahfouz, R., Al-Shaar, L., Hoteit, M., ... & Fuleihan, G. E. H. (2017). CYP2R1 polymorphisms are important modulators of circulating 25-hydroxyvitamin D levels in elderly females with vitamin insufficiency, but not of the response to vitamin D supplementation. Osteoporosis International, 28(1), 279-290.
42. Yu, C. K. H., Sykes, L., Sethi, M., Teoh, T. G., & Robinson, S. (2009). Vitamin D deficiency and supplementation during pregnancy. *Clinical endocrinology*, *70*(5), 685-690.
43. Nicolaidou, P., Hatzistamatiou, Z., Papadopoulou, A., Kaleyias, J., Floropoulou, E., Lagona, E., ... & Antsaklis, A. (2006). Low vitamin D status in mother-newborn pairs in Greece. *Calcified Tissue International*, *78*(6), 337-342.