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Assessment of vitamin D intake among Libyan women – adaptation and validation of specific food frequency questionnaire

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ABSTRACT
Vitamin D deficiency (VDD) has pandemic proportions worldwide. Numerous studies report on high prevalence of VDD in sunny regions like Near East and North Africa (NENA). Previous studies indicated that Libyan population was at risk of VDD. To contribute to the body of evidence, measurement of vitamin D status on children, adults, in Misurata region was conducted, and confirmed with validated dietary intake study. Serum 25(OH)D was analysed using electrochemiluminescence protein binding assay. Existing Food Frequency Questionnaires (FFQ) were adapted to Libyan Women Food Frequency Questionnaire (LW-FFQ). Repeated 24 h dietary recalls and LW-FFQ were employed in vitamin D intake evaluation. LW-FFQ was validated using 24 h dietary recall and vitamin D status as referent methods. The questionnaires included anthropometry and lifestyle information. Vitamin D status assessment revealed inadequate levels (25(OH)D < 50 nmol/l) in almost 80% of participants. Women (25-64 y) were identified as the most vulnerable group with vitamin D inadequacy present in 82% (61.6% had 25(OH)D < 25 nmol/l, and 20.2% had 25–50 nmol/l 25(OH)D). Average Vitamin D intake within the study sample (n = 316) was 3.9 ± 7.9 µg/d, with 92% participants below both Institute of Medicine (IOM) (10 µg/d) and European Food Safety Authority (15 µg/d) recommendations. Measured vitamin D status, in 13% of this group, correlated significantly (p = 0.015) with intake estimates. Based on self-report, consumption of vitamin D supplements does not exist among study participants. Additional lifestyle factors influencing vitamin D status were analysed. Only 2% of study participants spend approximately 11 min on the sun daily, 60.4% were obese, 23.1% were overweight and 71.2% reported low physical activity. These findings confirm previous reports on high prevalence of VDD in women across NENA, and in Libya. The situation calls for multi-sectoral actions and public health initiatives to address dietary and lifestyle habits.

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1. Introduction

In last decade, vitamin D deficiency (VDD) has been recognized as a pandemic worldwide [1–4]. Vitamin D, as a pro-hormone, has an important role in the endocrine system, regulating not only skeletal but immune, cardiovascular and neuroendocrine systems [5] and has autocrine function, on the intracellular level, facilitating gene expression [6]. Its deficiency is related to rickets in children, osteomalacia and other forms of skeletal diseases in adults. Growing body of evidence relates VDD with cardiovascular disease, some types of cancers, diabetes and mental illnesses [7]. Body can synthesize vitamin D in the skin when exposed to UV-β radiation. However, irregular and inadequate sun exposure impedes cutaneous vitamin D synthesis. Thus, body solely relies on dietary sources of vitamin D, which are scarce, and irregularly and insufficiently consumed [8].

Libya is categorized as countries in *complex emergency situations* (with severe child and maternal undernutrition and widespread micronutrient deficiencies) by World Health Organization (WHO), Regional Committee for the Eastern Mediterranean in the *Regional Strategy on Nutrition 2010–2019 and Plan of Action* [9,10]. There are several reposts from Near East and North Africa (NENA) region that identify high prevalence of micronutrient deficiencies and inadequacies among which is vitamin D, particularly in children and women of childbearing age [9–11]. Key obstacles in identification of population nutritional status and micronutrient deficiency in the region are lack of the monitoring and evaluation of

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Geolocation information: This study was conducted on the study sample from Misurata region, Libya.

nutrition and use of diverse methodologies in dietary intake/status assessments. Hence, the lack of harmonized data for evidence-based policy making hinders implementation of new policies and approaches to address the nutritional problem in this region [12].

Particularly, high rates of VDD has been recognized in NENA region, despite its plentiful sunshine throughout the year [13,14], where children, adolescents and women were majorly affected. In 2009, International Osteoporosis Foundation reported that women of NENA region had serum 25(OH)D around 25 nmol/L, which is considered as deficiency threshold [15]. Later, in 2016, Food and Agriculture Organization reported on high levels of VDD in children (which ranges from 9.5% in Qatar to 90% in Bahrain), in 76% Iranian school-aged children and in 62% Qatari teenagers and Saudi girls (81%). Highest VDD was reported in Saudi women, up to 85% [16]. Recently, few studies from Libya on vitamin D status identified that women of childbearing age were most at risk. In cross-sectional study in Bengazi, Libya, 58.4% women were in VDD, and 25% were in vitamin D insufficiency, while 26.1% men were deficient, and 21% were insufficient in vitamin D [17]. Another study from Tripoli, Libya, identified 69% nursing mothers having 25(OH)D < 30 nmol/L (mean ± SD 19.8 ± 5.5 25(OH)D (nmol/L)), and 30% nursing mother having 25(OH)D > 30 nmol/L (mean ± SD 35.4 ± 3.8 25(OH)D (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 [19]. Thus, their vitamin D intake rely greatly on the food they eat, which might not be enough to meet requirements.

This study has two objectives. Primarily, the study will assess vitamin D status in children, adult and elderly population in Misurata region. Secondarily, it will examine dietary intake of vitamin D among women in Misurata region using FFQ and 24 h dietary recall (24 HDR). The study will analyse anthropometric measures, physical activity and sun exposure behaviour as contributing factors of VDD.

2. Materials and methods

2.1. Study participants

A cross-sectional study was conducted between June and October 2015 to examine vitamin D intake and status level and associated factors in Libyan population. Data on Vitamin D status were analysed from available sample for 455 apparently healthy children and adolescents from 1 to 18 years old (8 males and 59 females), adults from 18 to 64 years old (64 males and 298 females) and elderly older than 64 years (3 males and 23 females) collected in Misurata Central laboratory and HIKMA hospital laboratory in period between June and July 2015. After statistical analysis of vitamin D status data, females from 25 to 64 years were identified as the most vulnerable group regarding the vitamin D insufficiency. With respect to that, a total of 366 women from this age group were recruited in Misurata between August and September 2015, on a voluntary basis, to participate in the study with 316 completing the FFQ and repeated 24 h dietary recall. A subsample of randomly selected participants from this group (n = 40, 12.7%), in the following text – validation group, was further examined in October 2015, which included blood sample and serum vitamin D status assessment as addition to the dietary questionnaires.

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Ethical Committee of the Misurata Central Laboratory for Medical Analysis – Ethics Reference: Eth 1103/18. Written informed consent was obtained from all participants.

2.2. Vitamin D status assessment

After 12 h of fasting, venous blood samples were collected from 40 randomly selected women who participated in the survey. The analysis for serum 25 (OH)D was done by electrochemiluminescence protein binding assay (ECLIA) using Roche Diagnostics, Cobas e411 analyser [20].

Vitamin D status was analysed according to cut-off values proposed by Institute of Medicine (IOM) in 2011: deficient (25(OH)D level <30 nmol/l), inadequate (25(OH)D level between 30 and 50 nmol/l), sufficient (25(OH)D level >50 nmol/l) [21].

2.3. Anthropometry

Anthropometric measurements were performed without shoes and jackets. Height was measured to the nearest 0.1 cm (Perspective Enterprises, Kalamazoo, MI, USA) and weight to the nearest 0.5 kg using calibrated weight scale. Waist circumference (WC) was measured using soft tape to the nearest 0.1 cm. Anthropometric status was analysed using classification according to Body Mass Index (BMI) categories (<18.5: underweight, 18.5–24.9: normal weight, 25.0–29.9: overweight, ≥30: obese). Percentage of participants at risk of metabolic complications according to the WC is calculated based on classification proposed by the WHO [22].

2.4. Libyan women-food frequency questionnaire (LW-FFQ) adaptation

In order to create the FFQ applicable on Libyan women, we adapted the existing questionnaire validated for assessment of vitamin D intake of young

Serbian women [23]. LW-FFQ was adapted for the Libyan traditional dietary habits and enriched with vitamin D food sources frequently consumed in Libya. Furthermore, specific questions related to sun exposure were modified to be culturally acceptable for the region.

The structure of the LW-FFQ is designed to cover a wide range of general questions: socio-demographic factors, lifestyle and physical activity, anthropometric measurements, consumption of supplements and special set of questions related to the sun exposure with or without clothes and hijab. The set of questions used for dietary intake assessment includes a wide selection of vitamin D food sources, foods traditionally consumed in Libya and most consumed foods from all food groups. Upon creation of the final version of LW-FFQ, translation from English to Arabic was conducted by two bilingual experts in nutrition and dietetics.

The LW-FFQ reflected the previous 3 months and was conducted within the face-to-face interview with a trained dietitian. Participants were provided with all necessary instructions related to frequencies of consumption and portion sizes in grams/millilitres presented on photographs as a part of the LW-FFQ. For the frequency of consumption, participants could choose one of the following options: 'never', 'once per month', '2–3 times per month', 'once a week', '2–3 times per week', '4–6 times per week' and 'every day' for each food item. All reported frequencies were converted to frequencies per day to enable analysis of daily food consumption and nutrient intake. The questionnaire contained 149 food items and 12 additional questions regarding the frequency of supplement use, as well as consumption of products that are voluntarily enriched with vitamin D and present on Libyan market.

2.5. 24 h dietary recall

Repeated 24 HDR was conducted as a referent method for nutritional assessment. The first 24 HDR was conducted within the structured face-to-face interview on the same day as LW-FFQ. The second 24 HDR was conducted by telephone interview within three weeks. Women reported all foods and beverages they consumed for the previous 24 h from the breakfast until the next morning. Food picture book was used for assessment of portion sizes.

Participants could assess the portion size of consumed food choosing one of the four photos depicting small, medium, large and extra-large portion for 145 food items and 11 different household measures and utensils.

2.6. Nutrient intake calculation

Nutrient intakes from LW-FFQ and 24 h dietary recall were estimated using combined data from West African Food Composition Data Base (WA FCDB), Turkish FCDB, USDA and Serbian FCDB [24–27]. The specialized Vitamin D FCDB created within the FP7 ODIN project was used for vitamin D food sources [28]. The total daily intake of energy, macronutrients, vitamin D and calcium were calculated using the dietary assessment tool Diet Assess and Plan validated by European Food Safety Authority (EFSA) [29,30]. Inadequacy of vitamin D intake was assessed according to both Dietary Reference Intake (DRI) proposed by IOM (10 μg/day) and the latest EFSA recommendations (15 μg/day), while calcium inadequacy was assessed by DRI proposed by EFSA (750 mg/day) [31,32].

2.7. Statistical analysis

Data on vitamin D status were analysed according to age, gender and 25(OH)D level categories, defined by cut offs, using chi square test. The mean and standard deviation (SD) were calculated for energy, macronutrients (total carbohydrates, fat and protein), vitamin D and calcium intake. Several techniques were applied to validate LW-FFQ against 24 HDR and vitamin D status level as referent methods. Relation between LW-FFQ and 24 HDR was determined by Pearson correlation coefficients for normally distributed variables and Spearman correlation coefficient for variables that did not follow normal distribution. Bland-Altman analysis, as an alternative statistical approach based on a graphical technique, was used as addition to the correlation coefficients to assess the agreement between LW-FFQ and 24 HDR [33]. A cross-classification analysis was applied on the subset of 40 participants to determine agreement between the LW-FFQ and both reference methods. To perform the cross-classification analysis, vitamin D intake from LW-FFQ and 24 HDR, as well as status data were classified as belonging to the same quartiles, same and adjacent (± 1) quartiles, opposite quartiles (± 2) or entirely misclassified (1st vs. 4th quartile).

Linear trends between vitamin D intake assessed by LW-FFQ and vitamin D status were calculated using linear regression analysis. A p-value <0.05 was considered statistically significant. All statistical analyses were performed using R software package (R Foundation for Statistical Computing, Vienna, Austria) [34].

3. Results

Study sample of 455 participants, for which vitamin D status was analysed, was divided on four age-groups: 1–10, 11–24, 25–64 and 64+. Mean value of vitamin D status among females was 52.8 ± 29.3 nmol/L while among males it was 52.8 ± 30.0 nmol/L. Significantly, more women (79.4%) had vitamin D status below 50 nmol/L, compared to 52% of male participants ($p < 0.001$) (Figure 1).

Based on these findings, female participants were further examined by age groups and mean value of vitamin D intake was at lowest level among women between 25 and 64 years of age (33.1 ± 28.4 nmol/L) followed by adolescents and young adults between 11 and 24 years (34.7 ± 28.2 nmol/L), elderly group (43.0 ± 32.6 nmol/L) and children (51.6 ± 36.0 nmol/L). Significantly, more adult females (81.8%) were deficient or had inadequate vitamin D status level compared to other age groups (Figure 2), which was analysed by chi-square test with Bonferroni correction ($p = 0.024$).

In the second stage of this study, after identification of the most vulnerable population group regarding the vitamin D status level, associated factors, such as vitamin D dietary intake, sun exposure, obesity status and supplementation were examined on the sample of 316 women 24–64 years old. The average age of participants was 33.0 ± 9.3 years, distributed in age groups 24–34 years (39.6%), 35–49 years (45.6%) and older than 50 years (14.9%). Majority of participants (53.5%) had tertiary education (including post-graduate), 13.6% had secondary education, 15.2% had primary education while 17.7% were illiterate.

According to anthropometric measurement, 60.4% of participants were obese, 23.1% overweight, 15.8% had normal weight, while 0.6% were underweight. Due to the high percentage of obese women, this group was further analysed for the obese classes. Out of 191 obese women, 59.2% belong to the obese Class 1, 33.5% to the obese Class 2, while 7.3% belong to the obese Class 3 (Table 1).

Supplements were used by 14.9% of women and most of them consumed multivitamins (44.7%), only

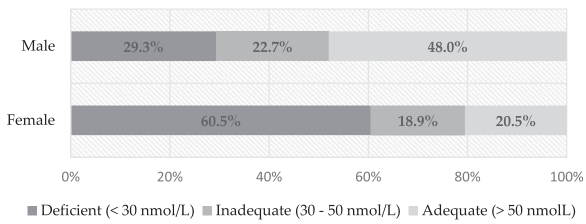

Figure 1. Distribution of participants according to the 25(OH) D cut-off levels by gender (chi-square test was used for comparison between gender and vitamin D status categories).

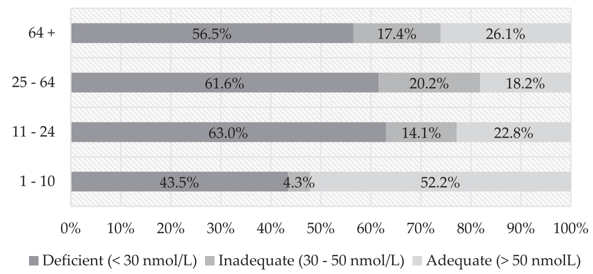

Figure 2. Percentage distribution of female participants according to 25(OH)D level and age groups (chi-square test was used for comparison between age groups and vitamin D status categories).

Table 1. Anthropometric measurements of study participants ($n = 316$).

	Mean	SD
Weight (kg)	78.1	13.8
Height (cm)	158.4	4.6
BMI (kg/m^2)	31.2	5.7
Waist circumference (cm)	94.0	16.8
Nutritional status by BMI kg/m^2	n	%
Underweight (<18.5)	2	0.6
Normal range (18.5–24.9)	50	15.8
Overweight (25.0–29.9)	73	23.1
Obese (≥30)	191	60.4
Obese class 1 (30–34.9)	113	59.2
Obese class 2 (35.0–39.9)	64	33.5
Obese class 3 (≥40.0)	14	7.3
Obesity co-morbidity risk (by WC)		
Normal WC	62	19.6
Risk level 1 (WC >80 cm)	58	18.4
Risk level 2 (WC >88 cm)	196	62.0

2.2% consumed vitamin D supplements, while 53.2% have not specified the kind of supplements they consumed.

Low level of physical activity was observed among study participants. At the moment of the survey, 71.2% reported low physical activity, 4.7% reported walking for less than 30 min per day as only physical activity, 13.9% walk between 30 and 180 min per day, while 6.3% walk every day for more than 3 h. Only 3.8% of participants reported vigorous physical activities.

In line with observed sedentary lifestyle among Libyan women, low sun exposure seems to be another noteworthy cause of low vitamin D status. Only 56 participants were sunbathing in previous three months, 73.2% of them were wearing hijab on the sun, 21.4% were wearing short clothes and sleeves, while 10.7% used sunblock creams.

Average daily energy, macronutrient, vitamin D and calcium intake assessed by LW-FFQ and 24 HDR are presented in Table 2. Correlations between intakes estimated by LW-FFQ and 24 HDRs were significant for energy and all analysed nutrients. That was the initial step of the LW-FFQ validation. Average vitamin D intake was 3.9 ± 7.9 µg/day and 4.4 ± 5.2 µg/day assessed by 24 HDRs and LW-FFQ, respectively. Calcium intake assessed by 24 HDRs was 726.9 ± 286.8 mg/day, while intake assessed by LW-FFQ was 751.2 ± 297.6 mg/day. Inadequate vitamin D intake, according to the recommendations proposed by IOM for adult female (10 µg/day), was observed among 88.6% and 91.4% of participants based on LW-FFQ and 24 HDRs, respectively. The same data were compared against latest EFSA recommendations (15 µg/day), and 92.4% participants had inadequate vitamin D intake, assessed by LW-FFQ, while 91.8% were below the recommended value when assessed by 24 HDRs. Calcium intake below 750 mg/day, as recommended by EFSA, assessed by LW-FFQ, was observed among 55.1% participants and among

Table 2. Daily energy and nutrient intake assessed by the average of the repeated 24 HDR and LW-FFQ with correlations between the estimates by applying questionnaires among Libyan women.

	Total sample (n = 316)					Validation group (n = 40)				
	24 h recalls		LF-FFQ			24 h recalls		LF-FFQ		
Nutrient	Mean	SD	Mean	SD	Correlation coefficient	Mean	SD	Mean	SD	Correlation coefficient
Energy (kcal)	2870.3	1104.5	2904.1	888.4	0.405***	3050.0	1051.3	2631.0	593.2	0.569***
Carbohydrates (g)	330.3	126.3	251.5	76.5	0.435***	359.8	110.2	231.7	60.6	0.524**
Fat (g)	105.1	55.6	146.3	65.3	0.383***	108.0	53.6	129.2	36.5	0.313*
Protein (g)	122.2	40.8	99.7	25.9	0.418***	127.7	34.7	96.6	22.7	0.457***
Vitamin D (µg)	3.9	7.9	4.2	5.2	0.600***	5.7	10.8	5.1	5.7	0.606***
Vitamin D (µg/1000kcal)	1.5	4.2	1.6	2.3	0.591***	1.6	2.8	2.1	2.5	0.714***
Calcium (mg)	726.9	286.8	751.2	297.6	0.590***	744.5	247.7	706.4	216.2	0.492***

*p-value < 0.05, **p-value < 0.01, ***p-value < 0.001.

59.5% participants, when calcium was estimated by 24 HDRs.

Figure 3 demonstrates the findings of the Bland-Altman analysis that indicated good agreement between LW-FFQ and 24 HDRs, as only 5.1% (16 cases out of 316) were outside defined limits of agreement.

The classification of vitamin D intake and status into quartiles was used to evaluate the agreement between classes of subjects for LW-FFQ, 24 HDRs and status (Table 3). The LW-FFQ classified more than 90% subjects into the same or same and adjacent quartile as 24 HDRs and 72.5% as vitamin D status level. Gross misclassification occurred for 2.5% between LW-FFQ and 24 HDRs and 7.5% between LW-FFQ and vitamin D status.

Vitamin D status examined on the validation group (n = 40) confirmed the findings from the first stage of the survey. Deficiency or inadequate vitamin D status was observed among 70% participants. Mean 25(OH)D level on the validation sample was 40.8 ± 32.5 nmol/L. A significant increase of 25(OH)D concentrations was identified with an increase of vitamin D intake (p = 0,015) as shown in Table 4.

4. Discussion

VDD, particularly among children and women, becomes imposing issue in public health in all NENA countries [16]. The substantial scarcity of good quality comparable data regarding vitamin D status and intake in the region is what hampers comprehending the span of the problem, establishment and implementation of policies and actions to eradicate VDD [13,35].

The objective of present study was to assess vitamin D status and contribute to the body of evidence on VDD situation in the region, particularly for Misurata region. The study, for the first time, assesses intake of vitamin D using validated nutritional tool – LW-FFQ, which was designed to capture vitamin D sources in Libyan diet and assess its

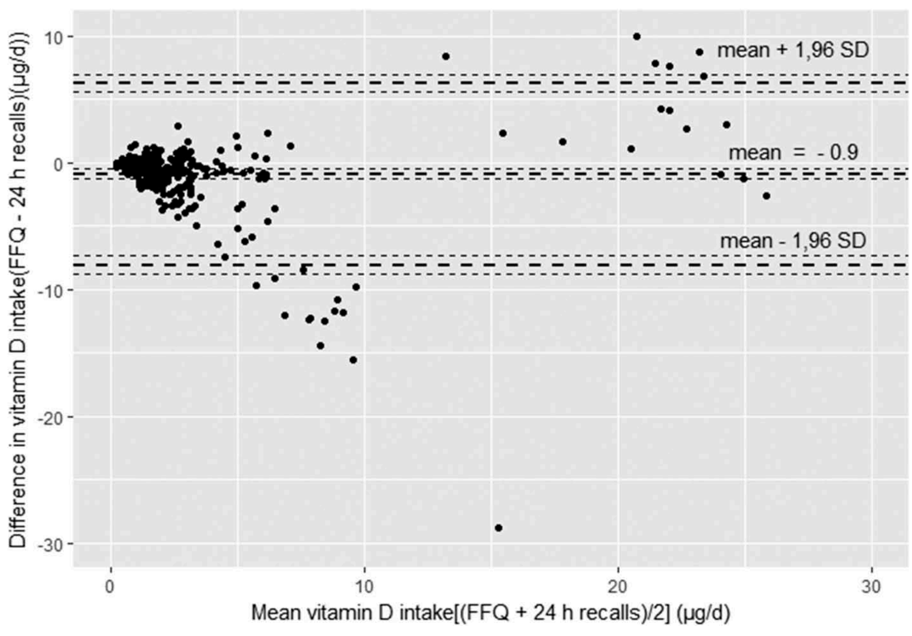

Figure 3. Bland-Altman plot assessing the agreement between the LW-FFQ and the average of repeated 24 HDRs for estimation of vitamin D intake.

Table 3. Cross-classification of vitamin D intake into quartiles by LW -FFQ and validation methods (24 HDR and status).

	Vitamin D intake assessed by FFQ			
Vitamin D intake/status assessed by	Same quartile (%)	Same or adjacent quartile (%)	Opposite quartile (%)	Grossly misclassified (%)
24 HDR	45	90	7.5	2.5
25(OH)D	30	72.5	20	7.5

Table 4. Estimated vitamin D status (25(OH)D nmol/L) and vitamin D intake estimated by 24 HDR by quartile of vitamin D intake estimated by LW-FFQ among Libyan women (n = 40).

			25(OH)D nmol/L		
Quartiles	Vitamin D intake (µg/day) – FFQ	*n*	Mean	95% CI	*p* for Trend
1st quartile	<1.7 (1.1)	10	32.3	22.4–42.1	0.015*
2nd quartile	1.7–2.5 (1.9)	10	25.3	16.0–34.5	
3rd quartile	2.5–6.6 (3.2)	10	41.4	17.3–65.5	
4th quartile	6.6–20 (13.3)	10	61.8	30.3–93.3	

intake in women. LW-FFQ was validated against 24 HDR and vitamin D status. High levels of agreements were observed between intakes assessed with LW-FFQ and 24 HDR while intake assessed with LW-FFQ correlated significantly vitamin D status. Besides that, vitamin D status assessed in validation group confirmed the low vitamin D status in initial study group. Low intake of calcium, below international recommendations, was identified in more than half of the participant by both nutritional tools.

One limitation of this study is non-representative sample regarding the age and gender distribution. However, since most participants were adult women, and results indicated VDD in this group, we decided to perform the vitamin D intake assessment on them. Besides that, we assessed other factors that could affect vitamin D status such as sun exposure behaviour, physical activity and anthropometric measurements. There are few studies conducted in Libya that report on low vitamin D status in women. One study from Benghazi region determined that 75% women had 25(OH) D <50 nmol/l [17], while the other from Tripoli identified 61% nursing mothers had 25(OH)D <30 nmol/l [18]. These studies report on very low consumption of vitamin D supplements and vitamin-D-rich food, while there are not many fortified foods in Libya, which was also confirmed in present study. Food fortification policies in Libya are not clearly defined. Fortification practices are on the voluntary basis and there are several fortified foods on the Libyan market with vitamin D, such as breakfast cereals, cocoa powder, milk, cheese, etc. However, for milk and cheese, content of vitamin D is not specified on the product label. This could be considered as the limitation of the study as these data could neither be added in the FCDB nor taken into account in the nutrient calculation, though 59.2% participants reported that they consume foods enriched with vitamin D. Particularly, study from Benghazi analysed consumption of vitamin D food sources, and identified that dairy products (milk, butter, yoghurt) are consumed among majority of women (72–89%), while fish is consumed less often – by 50% of them. Only 20% women reported on using vitamin D supplements [17]. In the present study it was identified that food groups with a dominant contribution to the total daily vitamin D intake, assessed by 24 HDRs, are fish and fish products (64%), followed by eggs (15.5%), meat (7%) and dairy (4%) (Table 5). However, fish is consumed by 4–59% women, while milk and chicken are consumed by 100% of them. Eggs are also significant source of vitamin D, consumed by majority of women (83%). Major vitamin D food sources selected based on 24 HDRs are shown in Table 6.

Numerous studies reported that clothing culture (veiling) and general avoidance of sun exposure, due to the cultural preferences and sun illumination intensity, are significant contributors to this situation in the whole region [5,13,15,19,35]. These findings were confirmed in our study by observing prevalence of sedentary lifestyle and low sun exposure. In line with this are sedentary, indoor lifestyle and a surge of overweight and obesity, up to 86% in women in the region [11], 70% overweight and 40% obese women in Libya [36]. Present study identified that prevalence of overweight and obesity in Libyan women is 23% and 60%, respectively, with WC at comorbidity risk lever 2 in 62% participants (Table 1). The obesity, and even more adiposity, has been positively correlated with low levels of 25(OH)D in previous studies. Adipose tissue is a depot of 25(OH)D and is difficult to be released into the circulation, which explains its lower values in serum 25(OH)D measurements in obese subjects [37,38]. On the other side, there are studies that argue that lower conservative cut-off values for defining VDD (25(OH)D <50 nmol/l) which make virtually all NENA women deficient, might not be appropriate. Since there is no standardized definition of VDD, any international evaluation and comparison on the prevalence in NENA countries might be misinterpreted and requires further studies that will define optimal biomarkers for hypovitaminosis vitamin D in the region [39,40].

Table 5. Daily intake of food groups and their contribution to total Vitamin D intake among Libyan women (n = 316).

	Intake of the food group (g/day)			Contribution to total vitamin D intake	
Food groups	Median	5th percentile	95th percentile	Pecentage	Vitamin D intake (μg/day)
Sea food and related products	45.0	45.0	459.1	63.6	2.46
Eggs and egg products	30.0	30.0	123.4	15.5	0.6
Meat and meat products	211.4	211.4	423.0	7.2	0.28
Milk and milk products	142.5	142.5	332.1	4.4	0.17
Other				9.3	0.36

Table 6. Major vitamin D food sources assessed by 24 h recall.

	Total sample	Consumers only	
Food name	Vitamin D (μg/day)	Vitamin D (μg/day)	Percentage of consumers
Gilthead bream, aquaculture	1.21	31.82	3.8
Sardine	0.97	24.19	6.0
Eggs	0.60	3.33	83.2
Fortified foods (cocoa, breakfast cereals)	0.28	7.07	21.2
Tuna	0.23	0.39	58.9
Chicken	0.14	0.21	100.0
Lamb meat	0.10	0.46	72.2
Milk	0.08	0.26	100.0
Butter	0.06	0.14	41.8
Bullet tuna (Auxis rochei)	0.04	3.17	1.3
Yoghurt	0.03	0.07	42.4
Processed cheese	0.02	0.04	43.7

To eradicate triple burden of nutritional transition in the NENA region, WHO The Regional Strategy on Nutrition 2010–2019 and Plan of Action sets the future targets:

(1) To reduce the prevalence of micronutrient deficiencies (MND)s: prevalence of calcium and VDDs among women of childbearing age, lactating women, children and the elderly needs to be reduced by 50%;
(2) To reduce the prevalence of diet-related noncommunicable diseases: obesity in children, adolescents and adults to be reduced by 35%.

The action plan recommends promoting healthy food consumption patterns to ensure diversity in the diet, nutrition education and supplementation programmes, especially for children and women. It encourages development of MND-sensitive food-based strategies such as food fortification and nutrition-sensitive agricultural interventions (bio-fortification of staple foods and local production of micronutrient-rich foods) [9,10,41]. Main arguments for food fortification and bio-fortification are that already existing food supply chains would allow to reach wider range of consumers, particularly those at risk, while they do not require a change in existing diets and food consumption patterns. These measures can address MNDs in situations where existing food supplies fail to provide adequate levels of certain nutrients in the diet (in emergencies, lack of infrastructures, under-developed markets) [42].

This, further, requires policy initiatives that will enforce food systems which encompass not only agriculture but trade, the environment, and health, power of the private sector and encourage consumers to demand better diets [43].

5. Conclusions

This study contributes to the development of harmonized research infrastructure in nutrition by providing validated nutritional tools and their application in identification of concrete diet-related problems. VDD in the whole NENA region, and so in Libya, has alarming proportions. Given the associated health implications such as obesity, non-communicable diseases (NCDs), MNDs in vulnerable groups– children, adolescents and women – it calls for multi-sectoral collaboration which will address dietary and lifestyle habits. Many of the relevant action plans are not implemented on regional and national level and there is urgent need to encourage governments and different stakeholders for joint actions in designing innovative and targeted solutions such as (bio)fortification of staple foods that will prevent VDD and related health consequences.

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Disclosure statement

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