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# Assessment of Knowledge, Attitudes, and Practices Related to Vitamin D Deficiency among Adults in Jordan: A Cross-Sectional Analysis

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**Abstract |** **Objectives:** Vitamin D deficiency is highly prevalent in Jordan and represents a significant public health concern. This study aimed to assess the knowledge, attitudes, and practices (KAP) of the Jordanian population regarding vitamin D deficiency. **Methods:** A cross-sectional study was conducted among Jordanian adults aged ≥18 years between October 2018 and January 2019. Data were collected using a structured, self-administered questionnaire. **Results:** Nearly all participants (99.7%) reported awareness of vitamin D. Media (53.6%) and educational institutions (45.9%) were identified as the primary sources of information. Most participants (82.6%) recognized sunlight as the main source of vitamin D, while 81.6% were aware of its role in preventing osteoporosis, and 78% believed that vitamin D deficiency causes bone and joint pain. However, knowledge of the recommended daily intake was notably low (13.9%). Although 60.4% of participants were not concerned about their vitamin D levels, attitudes toward sun exposure were generally positive. Approximately 72.3% reported enjoying sun exposure at least twice per week for ≤29 minutes, preferably during early morning hours, regardless of sunscreen use (42.8%). Positive practices included vitamin D supplementation (46.4%) and regular sun exposure (72.7%). **Conclusions:** Despite high awareness of vitamin D among Jordanians, gaps remain in knowledge regarding recommended intake and personal vitamin D status. Public health interventions focusing on education, supplementation, and food fortification are recommended to improve vitamin D status in Jordan.

**Key Words** Attitude, Jordan, knowledge, practice, vitamin D

## INTRODUCTION

Vitamin D (cholecalciferol) is a fat-soluble vitamin that is primarily synthesised in the skin through the activation of 7-dehydrocholesterol by ultraviolet B (UVB) radiation from sunlight. Additional amounts are obtained from dietary sources, including fatty fish such as cod, mushrooms, milk, eggs, and fortified foods [1]. Vitamin D undergoes initial metabolism in the liver, where it is converted to 25-hydroxyvitamin D [25(OH)D]. Subsequently, 25(OH)D is further hydroxylated in the kidney by the enzyme 1-alpha hydroxylase to form 1,25-dihydroxyvitamin D [1,25$(OH)_2$D], the biologically active form of vitamin D [2]. Nevertheless, circulating 25(OH)D levels are considered the most reliable indicator of overall vitamin D status and body stores [3]. Serum 25(OH)D concentrations above 30 ng/mL are regarded as sufficient, levels between 21–29 ng/mL as insufficient, and levels below 20 ng/mL as deficient [4]. Vitamin D deficiency remains highly prevalent worldwide, particularly among pregnant and breastfeeding women, postmenopausal women, as well as infants, children, and adolescents [5].

Vitamin D plays a crucial role in maintaining calcium and phosphorus homeostasis in the bloodstream, which is essential for optimal bone mineralization and skeletal health [6]. Deficiency of vitamin D, along with other contributing factors, is involved in the development of metabolic bone disorders, leading to osteomalacia in adults and rickets in children [7]. Beyond its role in bone health, vitamin D is also implicated in the prevention of several chronic diseases, including cardiovascular diseases, hypertension, diabetes mellitus, metabolic syndrome, autoimmune disorders, cancer, and depression. Moreover, vitamin D deficiency has been associated with an increased susceptibility to infections, highlighting its importance in immune function [1].

Vitamin D deficiency represents a major global public health problem [5]. Numerous studies have shown that women in many Arab countries, including Jordan, are particularly prone to vitamin D deficiency [8–14]. This high prevalence may be attributed to multiple factors, including limited sun exposure, lifestyle practices, darker skin pigmentation, hot climatic conditions, and prolonged breastfeeding without adequate calcium and vitamin D supplementation [10,11,15].

In Jordan, several studies have assessed vitamin D status across the population and consistently reported a high prevalence of vitamin D deficiency among different age groups, particularly among females, despite variations in reported deficiency rates [16–23]. However, to date, no study has quantitatively evaluated the population's fundamental knowledge of vitamin D, nor examined public attitudes and behaviors toward improving vitamin D status among Jordanians. Understanding the level of awareness, knowledge, and attitudes toward vitamin D within the Jordanian population is essential for informing effective public health interventions. Therefore, this study employed a random, representative sample of the Jordanian population to assess these factors. The findings are expected to support the development of targeted clinical and public health strategies, including health promotion and educational interventions, aimed at improving vitamin D status and reducing vitamin D deficiency in Jordan.

## MATERIALS AND METHODS

A cross-sectional study was conducted between October 2018 and January 2019 among adult males and females aged ≥18 years. Data were collected using a structured, self-administered questionnaire distributed to individuals attending pharmacies located in different districts across Jordan, as well as to undergraduate students at Zarqa University. Since the student participants originated from various regions of the country, they were considered to reasonably represent the wider Jordanian population. In addition, the questionnaire was administered online to reach a larger number of participants nationwide.

The survey aimed to assess participants' knowledge, awareness, attitudes, and behaviors related to vitamin D and sunlight exposure. The questionnaire was adapted from previously published studies [24–28] and further refined through consultation with academic dietitians and nutritionists. It consisted of three sections with close-ended, multiple-choice questions. Section A collected socio-demographic information, including age, gender, marital status, educational level, and monthly household income. Section B evaluated participants' sources of information about vitamin D, knowledge of its main sources, functions and health benefits, recommended daily intake, and the average duration of sun exposure required to maintain adequate vitamin D levels. Section C assessed attitudes and behaviors related to sunlight exposure, including time spent outdoors, frequency and seasonal preference for sun exposure, use of sunscreen and other protective measures, lifestyle factors such as smoking status, and practices adopted to improve vitamin D levels.

### Statistical Analysis

The collected data were analysed using the Statistical Package of Social Science Version 23 (SPSS version 23). Descriptive statistics were used to characterise the study population. Frequency tables were constructed and presented as percentages.

## RESULTS

The sociodemographic characteristics of the study population are summarized in Table 1. A total of 642 participants aged ≥18 years were included in the study. The majority of participants (90.3%) were aged between 18 and 39 years, while 8.6% were aged 40–59 years, and only 1.1% were aged ≥60 years. Females constituted 69.2% of the sample, whereas males accounted for 30.8%. Most participants were single (72.1%).

Regarding educational status, almost all participants were highly educated (94.9%). The reported average monthly household income was less than 500 Jordanian Dinars (JOD) for more than half of the participants (58.9%), followed by 500–999 JOD (29.3%). Geographically, the majority of respondents resided in central Jordan (86.4%), with smaller proportions from the northern region (10.9%).

### Knowledge and Awareness of Vitamin D

Table 2 summarizes participants' knowledge and awareness regarding vitamin D. Nearly all respondents reported having heard of vitamin D. Media sources were the most commonly reported source of information (53.6%), followed by educational institutions (45.9%). Other sources included primary health care centers, physicians, and medical professionals (36.0%), as well as relatives or friends (24.8%).

When participants were asked about the normal range of vitamin D levels, approximately half (52.6%) indicated that they did not know the correct range. In

Table 1: The socio-demographic characteristics of participants (n= 642 )

| Characteristics | No. (%) |
|---|---|
| Total | 642 |
| Age, years | |
| 18–39 | 580 (90.3) |
| 40–59 | 55 (8.6) |
| ≥ 60 | 7 (1.1) |
| Gender | |
| Male | 198 (30.8) |
| Female | 444 (69.2) |
| Education (years of completed formal schooling) | |
| Illiterate | 0 |
| 1–11 | 0 |
| 12 | 33 (5.1) |
| >12 | 609 (94.9) |
| Marital status | |
| Single | 463 (72.1) |
| Married | 164 (25.5) |
| Divorced | 12 (1.9) |
| Widowed | 3 (0.5) |
| Employment | |
| Unemployed | 51 (79.6) |
| Pharmacist/Health sector | 84 (13.1) |
| Governmental sector | 31 (4.8) |
| Private sector | 83 (12.9) |
| Family income/month (JOD) | |
| <500 | 378 (58.9) |
| 500–999 | 188 (29.3) |
| 1000–1499 | 37 (5.8) |
| >1500 | 39 (6.0) |
| Region | |
| North | 70 (10.9) |
| Middle | 555 (86.5) |
| South | 17 (2.6) |

contrast, 38.3% correctly identified the normal range (20–50 ng/L), while 9.0% provided incorrect responses

The majority of participants (82.6%) agreed that sunlight is the most important source of vitamin D. As they were allowed to choose multiple options, fatty fish (36.8%), milk (43.5%), cheeses (20.6%), cod liver oil (16.8%), mushrooms (5.6%), and whole wheat cereals (10.4%) were also among the correct responses regarding the sources of vitamin D [28]. Among all participants, 20.9% and 16.8% incorrectly chose fruits and vegetables, respectively, as sources of vitamin D.

Regarding the time needed to be spent outdoors in the sun to get enough vitamin D, 46.5% of participants answered incorrectly (less than 10 minutes/day), followed by 30% who reported the correct answer (10–20 minutes/day) [27-28], while 23.2% of them thought that at least 30 minutes per day is needed to be spent under the sun to get enough vitamin D. The question about the daily recommended dose showed that only 13.9% of the participants knew the correct answer (600 IU) [29], 21.3% answered incorrectly, and a large portion of respondents (64.8%) were unaware. Further, 50.3% of participants believed that taking calcium supplements helps maintain vitamin D levels, 23.4% answered negatively, and 26.3% reported they do not know.

The participants showed good knowledge about the causes of vitamin D deficiency, as 85.4% indicated that it is due to insufficient exposure to sun, and 60.7% indicated a lack of eating rich food with vitamin D; however, there was poor knowledge regarding other causes such as kidney disease (6.2%). The participants also showed a good awareness about the function and benefits of vitamin D, as 81.6% positively indicated that it prevents osteoporosis, and 51.2% of them answered that it aids in calcium absorption, followed by 48.3% who answered it prevents general weakness. Responses for other benefits were low, with 18.4% indicating that vitamin D prevents cancer, 18.7% acknowledging that it prevents chronic diseases, and a minority (7.8%) reporting that it is good for vision. When asked about the symptoms of vitamin D deficiency, 78% indicated pain in joints and bone, 35.2% selected delayed growth of teeth in children, 43.5% indicated delayed walking, and 20.9% chose deformed knee joint in children. Approximately one-third (31.2%) of participants related muscle pain to vitamin D deficiency, 32.4% believed it causes depression, and 10.1% related this issue to alopecia. A minority (9.2%) of them lacked this knowledge.

Regarding the question of whether there is a relation between vitamin D deficiency and other diseases such as cardiovascular diseases, diabetes mellitus, depression, hypercholesterolemia, cancer, and multiple sclerosis, 46.1% answered positively, 22.1% negatively, and 31.8% answered they do not know.

**Practice and Behavior**

Based on the results represented in Table 3, 39.6% of participants examined their vitamin D levels, whereas

Table 2: Awareness and knowledge of the respondents about vitamin D

| Variable | n (%) |
|---|---|
| Have you heard about vitamin D? | |
| Yes | 640 (99.7) |
| No | 2 (0.3) |
| From where you heard /learned about vitamin D? (multiple answer selection possible) | |
| Media (Newspaper, magazines, T.V., Internet websites) | 344 (53.6) |
| Educational institutions (school, college, university) | 295 (45.9) |
| Primary health care centres, physician, medical professionals | 231 (36) |
| Relatives, friends | 170 (24.8) |
| What is the normal level of vitamin D? (ng/L) | |
| <12 | 24 (3.7) |
| <20 | 34 (5.3) |
| *20–50 | 246(38.3) |
| Do not know | 336 (52.6) |
| What are the important sources of vitamin D? (multiple answer selection possible) | |
| *Sun | 530 (82.6) |
| *Milk | 279 (43.5) |
| *Fatty fish (e.g. tuna, salmon, mackerel) | 236 (36.8) |
| *Egg yolk | 197 (30.7) |
| *Cod liver oil | 108 (16.8) |
| *Whole wheat cereals | 67 (10.4) |
| Fruits | 134 (20.9) |
| Vegetables | 108 (16.8) |
| *Mushroom | 36 (5.6) |
| *Cheese | 132 (20.6) |
| Do not know | 50 (7.8) |
| How much time do you need to spend in the sun to get enough Vitamin D? | |
| <10 min | 293 (46.5) |
| *10-20 min | 189 (30) |
| 30-60 min | 95 (15.1) |
| >1 hr | 51 (8.1) |
| Don`t know | 14 (2.1) |
| What is daily needs for vitamin D? (IU) | |
| 200 | 113 (17.6) |
| *600 | 89 (13.9) |
| 800 | 24 (3.7) |
| Do not know | 416 (64.8) |
| Do you think taking calcium supplements helps in maintaining vitamin D levels in the body? | |
| Yes | 323 (50.3) |
| No | 150 (23.4) |
| I do not know | 169 (26.3) |
| What are the causes of vitamin D deficiency? (multiple answer selection possible) | |
| Hereditary | 78 (12.1) |
| Less exposure to sun | 548 (85.4) |
| Lack of eating rich food with vitamin D | 390 (60.7) |
| Kidney disease | 40 (6.2) |
| Respiratory infection | 12 (1.9) |
| Do not know | 47 (7.3) |
| Do you know the function and benefits of vitamin D? (multiple answer selection possible) | |
| Prevents osteoporosis | 524 (81.6) |
| Prevents general weakness | 310 (48.3) |
| Prevents chronic diseases | 120 (18.7) |
| Prevents cancer | 118 (18.4) |
| Aids in calcium absorption | 329 (51.2) |
| Good for vision | 50 (7.8) |
| Do not know | 15 (2.3) |
| What is/are the symptom/s of vitamin D deficiency? (multiple answer selection possible) | |
| Pain in joints and bones | 501 (78) |
| Delayed growth of teeth | 226 (35.2) |
| Delayed walking in children | 279 (43.5) |
| Deformed knee joint among children | 134 (20.9) |
| Muscle pain | 200 (31.2) |
| Depression | 208 (32.4) |
| Alopecia | 65 (10.1) |
| Do not know | 59 (9.2) |
| Do you think that vitamin D deficiency is related to other diseases like: cardiovascular, diabetes, depression, hypercholesterolemia, cancer and multiple sclerosis? | |
| Yes | 296 (46.1) |
| No | 142 (22.1) |
| Do not know | 204 (31.8) |

Abbreviations: Frequency (n); percentage (%), *indicates correct response

Table 3: Practice and behaviour of participants toward vitamin D deficiency

| Variable | n (%) |
|---|---|
| Have you ever examined your Vitamin D level? | |
| Yes | 251 (39.6) |
| No | 388 (60.4) |
| How do you feel about sun exposure? | |
| I like to expose to sun all the time | 91 (14.2) |
| I like to expose to sun sometimes | 373 (58.1) |
| I rarely expose to sun | 116 (18.1) |
| I avoid exposure to sun | 58 (9.5) |
| Do not know | 4 (0.6) |
| What time do you prefer to be exposed to sun? | 518 (80.7) |
| Early morning | 22 (3.4) |
| Noon | 42 (6.5) |
| After noon | 36 (5.6) |
| I avoid sunlight | 19 (3.0) |
| I usually go out at night but not during the day Don`t know | 5 (0.8) |
| In which season do you like to be exposed to the sun? | |
| Summer | 55 (8.6) |
| Autumn | 21(3.3) |
| Spring | 294 (45.8) |
| Winter | 263 (40.9) |
| All year | 9 (1.4) |
| How frequently you are exposed to sun (times/week)? | |
| 0–1 | 150 (23.4) |
| 2–3 | 201 (31.3) |
| More than 3 | 281(43.8) |
| Don`t know | 10 (1.5) |
| Duration of exposure | |
| 15 min or less | 313 (48.8) |
| 15–29 min | 168 (26.2) |
| 30–60 min | 98 (15.3) |
| More than 1 hr | 58 (9.0) |
| Don`t know | 5 (0.8) |
| What do you use most often as protection from sun? (multiple answer selection possible) | |
| Scarf | 264 (41.8) |
| Neqab | 25 (3.9) |
| Gloves | 20 (3.1) |
| Umbrella | 6 (0.9) |
| Sunscreens | 275 (42.8) |
| Do not use any protection | 259 (40.3) |
| Do you use sunscreen products containing SPF> 15? | |
| Yes | 192 (29.9) |
| No | 312 (48.6) |
| Do not know | 138 (21.5) |
| At what season you prefer to use the sunscreen? | |
| Summer | 168 (26.2) |
| Winter | 7 (1.0) |
| Both | 195 (30.4) |
| Don`t use | 272 (42.4) |
| How often do you use sunscreen? | |
| Always | 194 (30.2) |
| Sometimes | 125 (19.5) |
| Rarely | 71 (11) |
| Never used sunscreens | 252 (39.3) |
| Do you exercise? | |
| Yes | 189 (29.4) |
| Sometimes | 287 (44.7) |
| No | 166 (25.9) |
| Smoking status (cigarette) | |
| Non smoker | 436 (68) |
| Ex-smoker | 61 (9.5) |
| Current smoker | 74 (11.5) |
| Narghile smoker | 106 (16.5) |
| What practices do you apply to prevent vitamin D deficiency? (multiple answer selection possible) | |
| Exposure to sun light | 467 (72.7) |
| Take vitamin D supplement | 298 (46.4) |
| Drink 2 cups of milk | 123 (19.2) |
| Not using SPF contain creams | 57 (8.9) |
| Increase seafood in diet | 46 (7.2) |
| None | 11 (1.7) |

Frequency (n); percentage (%)

60.4% they did not. When asked about their feelings towards sun exposure, only 14.2% of respondents liked exposure to sun all the time, 58.1% liked to be exposed to sun sometimes, 18.1% preferred rare exposure to sun, and 9.0% avoided exposure to sun. Majority of them (80.7%) liked to be exposed to sun in the early morning, 3.4% at noon, 6.5% afternoon, 5.6% avoid sunlight, and 3.0% usually go out at night but not during the day. Participants preferred some specific season for sunlight exposure, with 45.8% preferring spring, followed by 40.9%, who liked winter, and a minority liked the two remaining seasons—summer and autumn (8.6% and 3.3%, respectively).

Regarding the frequency of their direct sun exposure, 43.8% of them spend >3 times/week, 31.3% spend 2–3 times/week, and 23.4% spend < 2 times/week. They varied in their duration of exposure to the sun: 48.8% of them spent 15 minutes or less, 26.2% spent between 15 and 29 min per day, 15.3% spent between 30 and 60 minutes, and only 9.0% of participants spent more than one hour in the sun.

The participants used different protection methods. A total of 42.8% responded that they used sunscreen, 41.8% used scarf, and 40.3% did not use any protection. Further, 29.9% of the participants ensured a sun protection factor level (SPF) > 15 when purchasing sunscreen products. It was also observed that 26.2% of respondents applied sunscreen in summer, 30.4% applied sunscreen in both summer and winter seasons, and 42.4% did not use sunscreen. About the frequency of applying sunscreen, 30.2% always used it, 19.5% sometimes used sunscreen, 11.0% rarely used it, while approximately one-third of them (39.3%) never used sunscreen.

Regarding involvement in any exercise, 68.3% of participants responded that they did not participate in any activity. Regarding involvement in any exercise, 25.9% of participants responded that they do not participate in any exercise, 29.4% do exercise on a regular basis, and 44.7% participate in an activity. When asked about smoking, 68% of the participants were not cigarette smokers, 11.5% were current cigarette smokers, and 16.5% were narghile smokers.

Lastly, when the participants were asked about what practices they apply to prevent vitamin D deficiency, 72.7% believed that exposing themselves to sunlight is enough, 46.4% thought taking vitamin D supplements, 19.2% believed that drinking two cups of milk daily protects them from vitamin deficiency, 7.2% reported that increasing seafood in diet improves vitamin D level, and only 8.9% thought that avoiding the use of sunscreen blockers improves vitamin D level.

## DISCUSSION

Vitamin D has received enormous attention recently because its deficiency is a global issue [5]. Vitamin D deficiency is known to cause a variety of health diseases beyond bone health problems, as confirmed by various studies [1]. Due to the increased prevalence of vitamin D deficiency in this country [17–23], there is a need to inform the general population about the source, role of vitamin D in daily life, and practices to improve the level of vitamin D. This is the first study to highlight a very significant issue of current knowledge, awareness and understanding about vitamin D and behaviour of Jordanian population. This is accomplished by taking a representative sample consisting of general people attending pharmacies distributed in different regions of the country and Jordanian students from a leading private university in the middle of Jordan (Zarqa).

### Knowledge and awareness

The results indicate that the Jordanian population sample heard about vitamin D (99.7%) and had good knowledge (38.3%) about the normal range of vitamin D. This is in line with previous studies [26-28, 30]. Media was the main source of information for approximately one-half of the participants in our study, which is higher than that of the study performed in the UK (25.3%) [28]. Educational institutions were the second most common source (45.9%) for participants. An important finding of our study is the minimal role played by health care centres, physicians, and medical professionals in developing health awareness among the general population in the society. This is in accordance with findings from a study in Kuwait, where the role of physicians was poor [25].

About 80–90% of vitamin D is acquired by cutaneous synthesis under the action of sunlight, while the rest (10–20%) is acquired through nutritional means [31]. Participants had good knowledge about this fact, as 82.6% indicated the sun as a major source of vitamin D, in line with studies performed in the UK and Kuwait [25,28-29]. They also had good knowledge about other sources, as they correctly chose from multiple options, such as milk (43.50%), fish (36.8%), cheeses (20.6%), liver (16.8%), whole wheat cereals (10.4%), and mushrooms (5.6%), among the other important sources of vitamin D.

Despite having good knowledge about the sun as a source of vitamin D, more than two-thirds failed to provide a correct answer regarding the needed time to be spent in the sun to get enough vitamin D (10–20 min) [29]. This is consistent with a study from Oman [27]. A minority (13.9%) of participants were aware of the correct daily recommended dose of vitamin D (600 IU) [29], while the majority were unaware (64.8%). However, approximately half (50.3%) were aware of the role of calcium supplements in maintaining vitamin D levels.

Our study also showed that the participants had good knowledge about the causes of vitamin D deficiency, as 85.9% related this to decreased exposure to sunlight, 60.7% indicated a lack of eating food rich in vitamin D, and a minority chose kidney diseases. In addition, participants knew that vitamin D benefits bone health by preventing osteoporosis (81.6%), which agrees with the findings from a study from Oman [27]. About 48.3% agreed that vitamin D prevents general weakness, in line

with the study from Oman (49.2%). Slightly more than half (51.2%) of the participants were aware of the role of vitamin D in aiding calcium absorption [6]. Responses about other benefits of vitamin D, such as prevention of cancer and chronic diseases, were low (18.4% and 18.7% respectively). Awareness of these benefits should be increased by health promotion campaigns, as was shown by a study conducted by Brand and colleagues [32], which demonstrated extremely high levels of awareness among their study participants after this type of campaign.

The results of the current study revealed good knowledge among participants about the effects of vitamin D deficiency, as 78% believed it causes bone and joint pain, which is in agreement with findings from a study from Kuwait (87.0%). Vitamin D affects muscular function by acting on specific receptors in skeletal muscle or through its effects on serum calcium and phosphate [33]. Approximately one-third of the participants (31.2%) related muscle pain to vitamin D deficiency, which is higher than that of a study conducted in Kuwait (21%) [25]. The participants showed variation in their responses towards the effects of vitamin D deficiency on children, including causing delayed growth of teeth (35.2%), delayed walking (43.5%), and deformed knee joints (20.9%). They also positively acknowledged the relationship between vitamin D deficiency and other diseases such cardiovascular, diabetes, depression, hypercholesterolemia, cancer, and multiple sclerosis, which is higher than responses gained in a study from Kuwait (29.5%) [25].

**Attitude and behavior**

An interesting finding was that 39.6% of our surveyed people performed their laboratory test of vitamin D status without caring to know its level to take any action towards improving it in the case of deficiency. Several factors affect vitamin D levels, including sunlight exposure, season, and diet [21]. Although majority of the participants reported good awareness regarding exposure to sunlight as a major source of vitamin D and their high interest in sun exposure (72.3%), resembling the positive attitude towards sun exposure in the UK [25]. Therefore, they exhibited a high sun exposure frequency (75.1%) and a moderate use of sunscreen and ointments (42.8%). Sunscreens can modify the effects of sunlight on cutaneous synthesis of vitamin D [34]. Thus, the use of sunscreen by a good proportion of the population indicates a decreased level of vitamin D in their serum. Our finding regarding sunlight exposure and use of sunscreens contrasts with that of a study performed in Kuwait (males and females) exhibiting a negative approach towards sunlight exposure by regular use of sunscreens and adopting other sun protective measures in their daily life leading towards inadequate amounts of vitamin D level [35]. Avoidance of sunlight exposure and higher use of sunscreen, especially in females, have been reported as a major cause of vitamin D deficiency, especially in females in Saudi Arabia [36].

In this study, participants had a positive attitude towards sunlight, as the majority of them reported they spent 15 minutes or less to 29 minutes daily in the sun, during the early morning, which is in contrast to the behaviour of participants in the study from Kuwait [25]. They also preferred exposure during the spring and winter. This means that they receive sufficient vitamin D from sunlight during March and April, but sunlight from November to February will not be effective, since it will not stimulate cutaneous synthesis of vitamin D [37].

Exercise is believed to be a protective factor against developing low levels of vitamin D [38]. In our study, we found that approximately one-third of the participants did not exercise, while a majority exercised either regularly or sometimes. In particular, practicing different types of sports to develop healthy lifestyles is spreading among Jordanians.

This study also examined smoking as one of the lifestyle habits that spread in society, which may cause vitamin D deficiency, since smoking is an inducer of an enzyme that increases vitamin D metabolism in the liver, thus leading to low serum levels of vitamin D [39]. This issue applies to cigarette smoking and water pipe smoking (narghile). Responses were low, probably because females represented the majority of the study population. A new phenomenon currently spreading in the sampled community is the use of electronic cigarettes, which requires evaluation regarding their effect on vitamin D status.

To improve the levels of vitamin D, the participants indicated the practice of certain activities. Optimum exposure to sunlight and lifestyle modifications, such as physical exercise, may help in preventing the deficiency state. Since sunscreens may modify the effect of sunlight on cutaneous vitamin D synthesis [34], it is necessary to avoid using it all the time, and it is advisable to spend 10–15 minutes in the sun before applying sunscreen products [24]. It would be desirable to clinically utilise vitamin D supplementation and food fortified with vitamin D to avoid the complications of vitamin D deficiency. In this study, around half of the participants believed in taking vitamin D supplements to improve their vitamin D status as one of positive attitudes. This issue is similar to them perception of a study from the UK (43.5%) [28].

## Limitations

There are some limitations to be considered in the present study. First, no questions were included about working hours, which could be a barrier to sun exposure for a number of participants. Secondly, supplement use and kind of supplement should be investigated in more details. Finally, other sub-groups, such as children, young people, elderly people, and pregnant, menopausal, and breastfeeding women, should be targeted in such kind of studies, given that there is an association between maternal vitamin D levels and breastfeeding [31]. Therefore, future nationwide studies should consider assessing the serum 25(OH)D levels of participants.

## CONCLUSIONS

The prevalence of vitamin D deficiency is a worldwide epidemic and an alarming issue in the countries of Middle East including Jordan. The threat of vitamin D deficiency to public health and its link to chronic diseases has been highlighted in a vast amount of literature review [5]. The present study quantitatively examined knowledge, attitude, and practice towards vitamin D deficiency in a representative sample of the Jordanian population.

The majority of participants possessed good knowledge about vitamin D, and they identified sun exposure as the main source of vitamin D. However, there is a lack of consistency between knowledge and attitude towards improving vitamin D levels in their sera. This indicates the need to improve awareness among the Jordanian population by providing specific guidelines about the frequency, duration, optimum season, and amount of exposure to sunlight required. This may be accomplished through organizing health promotion campaigns, workshops, conferences, and health awareness programmes that require the participation of media and health care centres, physicians, and health care professionals. These activities should emphasise physical exercise, outdoor activities, lifestyle habits such as smoking and the recommended daily dose of vitamin D to improve the status of this vitamin. Although this study focused on adults > 18 years old, it is important to convey this information to other sub-groups, such as children, teenagers, pregnant, breastfeeding and menopausal women and elderly people, since they are considered risk groups for developing vitamin D deficiency. Information should be explained accurately and clearly and transmitted into simple, food-based terms to reach illiterate people. There should also be effective strategies from the government to fortify a range of products with vitamin D to reach all population subgroups, as done in many countries [28]. The role of health care professionals, especially physicians, should be improved through research about the current recommended daily allowance (RDA), which seems to be low [40]. A suggested reasonable approach is the annual monitoring of 25(OH)D concentration in a healthy population targeting the above-mentioned subgroups.

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