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A Cross-Cultural Systematic Review of Vitamin D Deficiency in Women

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Abstract: Vitamin D deficiency has been reported in several cultures and regions, including the Middle East, North Europe, and Australia. In this review, we summarize and discuss existing studies on factors underlying vitamin D deficiency across different regions. In particular, we explain key roles played by lifestyle, including sun exposure, season change, diet, and clothing (concealing vs. non-concealing) as factors leading to vitamin D deficiency. We further discuss gender differences in vitamin D levels and, the impact of vitamin D supplements on cognition. The introductory section of this paper focuses on introducing vitamin D deficiency and highlighting the prevalence of vitamin D deficiency in Eastern countries. Here, we also provide a comparative literature analysis not only based on Eastern and Western countries but also compare the prevalence of vitamin D deficiency between males and females. Our review provides key information on potential life changes that help increase vitamin D and protect against the development of several disorders.

Keywords: Vitamin D deficiency; Cultural differences; Systematic review; Diet; Gender; Women health.

1 Introduction

Vitamin D is an important nutrient that can be obtained either through diet or exposure to sunlight. One study, however, found that diet rich with vitamin D alone cannot protect against vitamin D deficiency without sun exposure [1]. Due to its relationship with sun exposure, vitamin D has been often termed the sunshine vitamin [2]. There are many factors that can influence vitamin D levels, including what region of the world someone lives in, skin pigmentation, season change, diet, and exposure to the sun, which can be influenced by type of clothing worn [3]. Further, while in the past some argue that the use of sunscreen may increase the prevalence of vitamin D deficiency, this was found not to be correct in a recent review study [4].

Foods that contain vitamin D are limited. However, some of the food that include vitamin D are fatty fish such as cod liver oil, salmon, tuna, maceral, as well as foods such as eggs and mushrooms (depending on the amount of sun exposure they get while growing). Vitamin D can be

Obtained from other foods that including some dairy products, such as milk, margarine, orange juice, grains and some cereals that have vitamin D micronutrients added to them [3].

There is no set measure used to rank vitamin D but, the general cut off scores include deficiency being levels from 30 nmol/L (12 mg/L) to 75–80 nmol/L (30–32 mg/L) and, sufficiency being levels from ≥ 50 nmol/L (20 mg/L) to ≥ 75 –80 nmol/L (30–32 mg/L). In the context of vitamin D, nanomoles (nmol) per liter (l) is the amount of vitamin D in the form of molecules in a fluid volume, usually, a collected blood sample. Several studies reported that vitamin D deficiency has psychological and physical impacts [5,6,7,8], including impaired bone growth, osteoporosis, diabetes, obesity, among other disorders. Accordingly, it is important to investigate factors leading to low levels of vitamin D across different cultures and genders.

There are reports of vitamin D deficiency in Eastern and Western countries. Importantly, as we discuss below, there are different factors underlying the prevalence of vitamin D

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deficiency in Eastern and Western countries. There are a multitude of studies on vitamin D deficiency in the Arab Gulf [5, 6, 8]. Most of these studies have reported that there is a high prevalence of vitamin D deficiency in Eastern countries, including the Arab Gulf. It has been argued that the Middle East, including the Arab Gulf, has the highest rate of vitamin D deficiency in the world [9].

Although the Arab Gulf is characterized by sunshine for most of the year, its residents are still low in vitamin D due to reduced exposure to sun. This is evident in 66% of infants born in Kuwait who are reported to have vitamin D levels below 30 nmol/l, and, 96% of infants who have levels below 50 nmol/l. As for children, 38% of Qatari children have vitamin D levels below 50 nmol/l. In adolescents, 62% have vitamin D levels below 50 nmol/l (10). Statistics of populations in Saudi Arabia reveal a similar pattern to that of Kuwait, in which a study shows that 81% of a sample of females had vitamin D levels below 30 nmol/l. Low vitamin D levels are also reported in Western countries, although to a lower extent than that of Eastern countries. For example, a French study revealed that only 14.2% of women had inadequate dietary vitamin D intake [11].

This review study will explore factors relating to low vitamin D levels and their implications as well as suggest possible interventions that could improve such circumstances. By doing so, this review paper will review several empirical studies to evaluate the effects of lifestyle (including sun exposure, diet and living situations) as well as gender differences related to vitamin D levels.

2 Methodologies

Method

The following databases were used in our search: Pubmed, ProQuest, PsychInfo, and Google Scholar (see Figure 1). Our search included the following a combination of two key words. The first word was vitamin D. The second key word was one of the following: culture, lifestyle, diet, gender. variations of these words were also used in our search. Further, we have carefully examined each paper to insure the goal of the study is related to vitamin D or vitamin D deficiency. We have filtered out studies that were conducted on animals and/or not related to the goal of the current study: gender and lifestyle in relation to vitamin D.

Vitamin D levels in Eastern Countries

[12] investigated vitamin D levels in Saudi medical school students. Vitamin D levels in 95 males and 103 females were low. The research defined vitamin D levels as follows: normal as greater than 75 nmol/l, deficiency as below 50 nmol/l, and insufficiency as between 52 and 72 nmol/l.

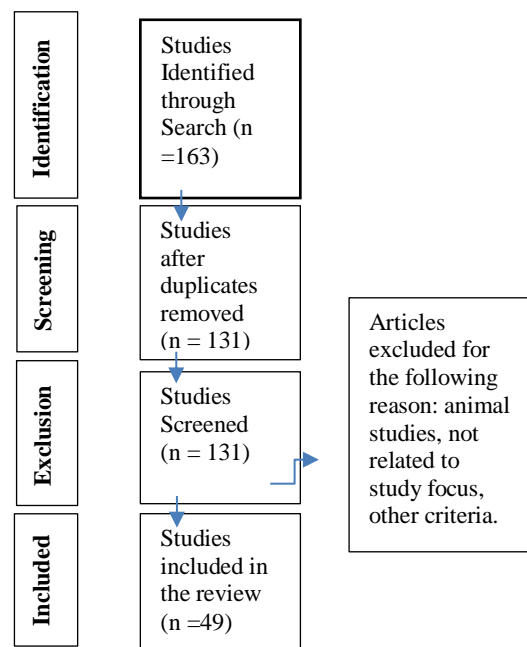


Figure 1: Our systematic review search method.

Findings of the study included the percentage of deficiency being 92.64% among males and 99.03% among females. In total, 96% of participants had deficiency and 4% had insufficiency. The mean for vitamin D levels was 26.83 nmol/l in males and 16.03 nmol/l in females. Both male and female students were not exposed to sufficient sun, and their diets were supplemented with vitamin D [12].

Factors underlying common vitamin D deficiency among Middle Eastern women is insufficient exposure to sunlight, which is a paradox for this sunny region. Some studies found that the amount of skin exposure to sunlight is a main factor related to a reduction in vitamin D levels [13]. Women specifically in Middle Eastern regions may not have sufficient skin sun exposure because they shield themselves from the sun either to avoid extremely hot weather or because of their conservative style of dress. Along these results, a recent study found that veiled women have the lowest vitamin D levels [14], but for different results see [15].

A study performed in Oman indicated that vitamin D deficiency is also prevalent among Omani women. Forty-one healthy women aged between 18 and 45 years participated in research by [16]. Similar to other studies, participants were asked to complete a questionnaire regarding their duration of sun exposure, nutrition, and clothing preferences. The study reported that most of the participants had a 25(OH)D level less than 50 nmol/L, which is considered vitamin D deficiency. Findings of the research indicated a strong and significant correlation between vitamin D and lack of sun exposure and food intake [16], which supports poor

outcomes due to low sunlight exposure and inadequate nutrition lacking vitamin D supplementation.

Studies also report the prevalence of vitamin D deficiency in Saudi Arabia (e.g., 17). [18] investigated of the commonality of vitamin D deficiency rickets in relation to sun exposure and calcium intake in 433 females aged between 12 and 15 years in Saudi Arabia. Participants blood and bone results, as well as their diets and sun exposure were reviewed. The findings of this study indicated that 81% of participants (corresponding to 350 girls) had low vitamin D levels between 2.2 and 24 nmol/l. When dietary habits of the participants were considered, the consumption of dairy products was not common as only 36% of participants had daily dairy consumption. In relation to participants' sun exposure as a crucial source of vitamin D, 19% of participants with low vitamin D claimed to never be exposed to the sun while 67% of participants claimed to be exposed to the sun for less than 15 minutes a day, whilst 75% claimed to have indirect sun exposure (18). Such findings suggest that females with lower vitamin D levels generally experience minimal sun exposure due to sociocultural reasons, lack of awareness on the importance of sun exposure for bone health, and cosmetic reasons. In addition, lack of skin exposure to the sun was found in lower class families in Saudi Arabia, possibly due to ultraconservative cultural values [18].

By comparing gender differences of vitamin D levels, a consecutive sample of 50 Saudi married couples participated in a cross-sectional study carried out in Riyadh, Saudi Arabia. The researchers collected data using a questionnaire to determine the risk factors and dietary habits of participants. [19] found that males were exposed more to the sun, were more able to wear light weight clothes at home, and had more dietary intake of milk as well as soft drinks than females [19]. Based on this result, it was not surprising that males exhibited higher vitamin D levels than females in which, vitamin D deficiency among females (less than 25 nmol/l) was 70%, whereas it was only 40% in males. Therefore, exploring vitamin D levels and gender differences, male's physical activity and milk intake were identified as statistically significantly positive independent predictors of higher vitamin D levels in a multivariate analysis. Moreover, female's sedentary lifestyles and low milk consumption were independent predictors of lower vitamin D levels [19] This research supports the importance of sun exposure and nutrition when regarding vitamin D levels. Along these lines, a study in the United Arab Emirates found that a lack of sun exposure was associated with low levels of vitamin D in female students [20].

A study including 340 healthy volunteers in Qatar was conducted between 15 January 2007 and 15 January 2008. Participants were asked to complete a diary to indicate their daily duration of sunlight exposure and consumption of vitamin D supplements. The study outlined the mean overall vitamin D level as 11.7 ng/ml in which vitamin D levels were lower in females (10.3 ng/ml) than in males (13.7 ng/ml).

However, overall, the mean vitamin D status was less than 30 ng/ml in 97% of participants. Moreover, 87% of the participants exhibited an even worse vitamin D level of less than 20 ng/ml. Hence, this study indicates that the prevalence of vitamin D deficiency requires further attention in Saudi Arabia and many other Middle Eastern countries [21].

Two studies, one from Turkey [22] and another from Bangladesh [23] further outlined the importance of sun exposure for vitamin D supplementation by comparing women who wore concealing clothes (veil in Bangladeshi) with those who wore non-concealing clothes. The results of the studies supported previously reported results [12, 16, 19, 21, 10, 17, 18]. That is, women who wore concealing clothing suggested as having lower vitamin D levels than females who wore concealing clothing because their skin was more exposed to sunlight. Results of this study also urging for greater sun exposure to increase vitamin D levels.

In addition to a lack of exposure to sunlight, there are other cultural practices that also impact vitamin D levels in Eastern countries. For example, Middle Eastern women generally practice prolonged breast feeding without vitamin D supplements [13], which could have a negative influence on their health. This is supported by lactating women being found to have vitamin D concentrations below 30nmol/l, which might increase the consequences of vitamin D deficiency [10, 24]. In addition, some studies also found that obesity is related to vitamin D deficiency in the United Arab Emirates (25), but for different results, see [26].

Vitamin D deficiency is also reported in other Eastern countries. For example, [27] investigated factors underlying vitamin D status of school-aged children in regions of Central Ethiopia. In this study, the researchers gathered data regarding the age and gender of each participant, amount of exposure to the sun, their body composition (body weight, height, and triceps skinfold thickness) as well as their Body Mass Index (BMI), lifestyle, and skin tone. Results show that vitamin D deficiency being more present in 42% of the participants, 61.8% in children in urban areas and 21.2% in children in rural areas. [27] suggest that their findings could be related to rural children's more traditional lifestyle, which may involve greater sun exposure than that of children living in urban areas. Another factor could be the level of education of mothers of participants. Participants whose mothers had higher levels of education contributed greatly to their likeliness to behave in a sun-safe conscious way by limiting sun exposure and using sun protectors such as sun screen. On the other hand, a positive contributor to vitamin D levels included participants' lifestyle in terms of diet. A common Ethiopian food consumed is bread called Injera which is produced using fermented yeast, in which the process of fermentation includes sun exposure, resulting in the bread being a good source of vitamin D. However, individuals living in urban areas may be of higher socioeconomic status and consume more vitamin D rich meats that participants in rural areas rarely consume but, would instead obtain vitamin D as a source of sun exposure instead. An additional finding

includes overweight or obese individuals being more vitamin D deficient than participants who were not overweight [27].

Vitamin D levels in Eastern Individuals living in the West
Several studies have reported a high rate of vitamin D deficiency among Arab and Eastern women residing in Western countries [28]. Interestingly, low vitamin levels were also reported in Arab-American women living in Michigan, which is possibly due to clothing style and/or diet [29]. Similar results were also reported among Arab women living in Denmark [1].

To explore predictors of vitamin D deficiency, [30] recruited Norwegian immigrants born in Middle Eastern countries. A total of a 1000 participants in their mid to late thirties born in Turkey, Sri Lanka, Iran, Pakistan, and Vietnam were included in the study. Participants' vitamin D levels were measured through blood sample collection using radioimmunoassay. To explore factors related to vitamin D intake, participants were questioned regarding their diet, intake of supplements, physical activity and education. The findings of the study included participants born in Turkey, Sri Lanka, Iran, Pakistan, and Vietnam overall having vitamin D deficiency. Moreover, Pakistani immigrants were most deficient and Vietnamese immigrants were least deficient when comparing immigrant ethnic groups. In immigrants born in Turkey, vitamin D deficiency was indicated to be lower with older age. Furthermore, vitamin D levels were overall suggested to differ across seasons. In June, vitamin D levels were higher than they were in April or May. Regarding dietary supplementation, the study reported that cod liver oil and fish oil supplements contributed to better vitamin D levels except in immigrants born in Vietnam. The consumption of fatty fish was also an indicator of better vitamin D levels, especially in Sri Lankan and Vietnamese immigrants who consume fatty fish often in their diets. Regarding education, it was found that greater years of education was related to better vitamin D levels suggestively due to education providing more chances of employment and being outdoors [30]. Similar findings were also reported in the Netherlands. Specifically, [31] found that vitamin D levels are significantly lower in children from African, Asian, Turkish, and Arab background in comparison to children from European background.

It is suggested that mother's levels of vitamin D affect their unborn children during pregnancy. Madar and colleagues [32] have explored vitamin D levels of non-Western immigrants from Pakistan, Turkey, and Somalia living in Norway and their children who were born in Norway. This study has also explored the factors associated with vitamin D and, how infant-mother relation can also affect infants' levels of vitamin D. [32] recruited 119 mothers and their infants from a hospital they regularly attended. The study included collecting blood samples from both the mothers and their infants to measure vitamin D concentrations. The criteria for deficiency was below 25 nmol/L and severe deficiency being less than 12.5 nmol/L. To further evaluate vitamin D levels, a questionnaire was provided by nurses for mothers to provide information on the infants feeding practices, the use of supplements such as cod liver oil, the

mother's education, number of years living in Norway, sun exposure, and intake of foods containing vitamin D. Findings of the study revealed a relation between mothers and infants. When mothers had vitamin D deficiency, so did their infants although born in a Western country. Severe vitamin D deficiency was especially found in infants who were breastfed by their mothers, did not take supplements and had little sun exposure [32]. This means that if a mother is low in vitamin D, her breastmilk may lack vitamin D, leading to breastfed infants having a lower than usual vitamin D levels than infants who feed on formula milk. Therefore, it may be essential for pregnant or breastfeeding mothers to have regular blood samples examined to ensure that they do not lack in vitamins such as vitamin D, which could potentially affect the nourishment of their infants.

One study explored vitamin D deficiency among adult Australians of European and non-European origin aged 25 to 95 years [33]. The study used the form of a survey and questionnaires and collected data from a total of 11,218 individuals around Australia, including Victoria, Western Australia, and the Northern Territory. Information collected from participants was their residential location (as well as rural or urban areas of living), education, country of birth (European such as Australia, Canada, New Zealand or non-European such as Asia, Middle East, Pacific Islands, Aboriginal Australians and Strait Torres Islanders), height, weight, Body Mass Index, smoking status, and physical activity. As well as participant information, blood specimen samples to analyse serum 25(OH)D levels across different months to compare seasonal differences of vitamin D levels was conducted. Findings of the study included a low percentage of 4% of Australians with vitamin D levels less than 25 nmol/L; and 31% of the population to have vitamin D levels less than 50 nmol/L. In regard to age, vitamin D levels were lower among older populations, especially individuals aged 75 years and older and those who did not engage in physical activity for at least two and a half hours a week. In relation to ethnicity, non-Europeans were four times more likely to have deficient vitamin D levels, which could be related to greater melanin in the skin and less vitamin D absorption. In terms of seasonal changes influencing vitamin D levels, participants were found to have deficiency more in the winter/spring than during summer/autumn and also varied depending on living region. For example, populations living in the northern regions of Australia were less vitamin D deficient than populations living in southern regions during summer/autumn. These findings could be influenced by factors such as conscious sun safety behaviour where individuals take precaution when in the sun due to risks of skin cancer, Australian diets not being rich in vitamin D sources, and increases in the rates of obesity in which individuals may not engage in much physical activity outdoors for sun exposure [33].

Vitamin D levels in Western Countries

The prevalence of low vitamin D is not as high in Western countries, in comparison to Eastern countries (but for a

different view, please see [34]. Furthermore, as in Eastern countries, vitamin D deficiency is more common among females than males in many Western countries, including Australia [35]. Similar to Eastern countries, individuals in the West who practice more safety behaviours have lower vitamin D levels, and individuals who are more educated are more likely to have better vitamin D levels [32,33,16, 27].

[37] And [36] conducted a study exploring the relation between vitamin D, obesity, and gender in 1,737 Norwegian women and 389 men of different age ranges. To assess vitamin D levels, radioimmunoassay was conducted, classifying deficiency as levels ≤ 50 nmol/l. For comparative analysis of vitamin D and obesity, participants were grouped based on their Body Mass Index as follows: underweight, normal, overweight, obesity degree 1, obesity degree 2, and super obese degree 3. Vitamin D levels were found to decrease as individuals Body Mass Index increased. That is, vitamin D was found to be lowest in severely obese individuals in which high body fat, which vitamin D is collected and stored, slowly releasing into to the body to make use of it. Not only does obesity have negative impacts on vitamin D but, it also impacts the lifestyle of individuals, which in turn further impacts their low vitamin D levels. Severely obese individuals may require larger clothing, covering up their skin more than usual sized clothing, limiting skin exposure to the sun and, have limited mobility, reducing the amount of time they spend outside and their exposure to sun as well. In terms of gender, obesity was found to affect women's vitamin D levels more than men, even if they have the same Body Mass Index as their body fat content and distribution is generally higher and more widespread. As explained previously, this means that vitamin D is stored more in women's fat content and used more slowly in the body than vitamin D a man's fat content stores [37]. Such findings highlight that not only does lifestyle affect vitamin D levels but also weight.

[38] studied that vitamin D levels and the benefits of vitamin D intake in a sample of Canadian women. They found that vitamin D was low in winter in comparison to the rest of the year. Although all women in the study were residing in Canada, vitamin D was generally lower in black women than white women, suggesting melanin could be a contributing factor to vitamin D levels. In winter specifically, the diet of women did not influence their vitamin D levels. That is, women consuming vitamin D rich foods such as milk and consuming vitamin D supplements did not significantly improve their vitamin D levels. To elaborate, in comparison to women who did not consume any vitamin D rich foods or take vitamin D supplements, their vitamin D levels was approximately 5% lower than women who did consume vitamin D. However, in the summer, vitamin D consumption was related to improved (or better) vitamin D levels but, this could be more related to the change in lifestyle pattern. In the winter, there is not much sun exposure if people are outside and, people tend to do more outdoor activities during the summer [38].

Conclusion

The findings of studies reviewed in this section suggest that vitamin D deficiency is prevalent among females in Eastern than in Western countries. Further, we found that a large percentage of Arab and Eastern women living in the West suffer from vitamin D deficiency, due to similar reasons to those of women in Eastern countries. This suggests that cultural reasons, rather than country of residence in general, are related to vitamin D levels.

In addition, our review show that there are different factors underlying vitamin D deficiency in Eastern and Western cultures. Factors influencing low vitamin D levels among majority of Eastern populations include clothing style, sedentary lifestyle, low socioeconomic status, low educational level, and urban living [13, 39]. As discussed above, women's level of education was also found to be related to vitamin D levels and the intake of supplements; the more educated the greater chances of taking vitamin D supplementation [32]. This is a promising finding which suggests that educating people on the effects and benefits of vitamin D could play a role in their attendance and adherence to taking vitamin D supplements. Along these lines, a recent study found that educating postmenopausal women in Korea about vitamin D diet was associated with a reduction in vitamin D deficiency [40].

Vitamin D deficiency is less common in Western countries. Factors underlying the prevalence of vitamin D deficiency in Western countries are obesity and winter season. Individuals who have a higher Body Mass Index and are obese are more likely to have lower vitamin D, because vitamin D is stored for longer periods in their fat can is difficult to distribute around the body, thus not allowing the body to thrive on the vitamin D is has stored. Moreover, it is apparent that similar to Middle Eastern countries, women are more likely to experience greater issues with vitamin D than men [16,37]. In sum, it is suggested that attention should be paid to educating individuals on the importance of vitamin D and how to obtain it from many sources. This includes food sources (e.g., milk) as well as skin exposure to the sun, since skin exposure alone may be a sociocultural challenge and restraint experience by individuals in regions such as the Middle East. Other studies have suggested that taking supplements with vitamin D, multivitamin, or calcium can also increase vitamin D in women [41].

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Conflict of Interests

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