Vitamin D Status of Patients Visiting Health Care Centers in the Coastal and Inland Cities of Saudi Arabia

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ABSTRACT

Background: Vitamin D insufficiency is increasingly becoming a worldwide problem and is even more pronounced in the Middle East, especially among the women and children.

Methods: Blood samples were collected from 2,129 subjects visiting the outpatient clinics for various reasons in the cities of Dammam and Al-Ahsa in Saudi Arabia. Total 25-Hydroxy Vitamin D levels were analyzed using high performance liquid chromatography.

Results: Around 72% of the subjects in both Dammam and Al-Ahsa had vitamin D deficiency. The proportion of females with vitamin D deficiency was higher than males in both cities. Average vitamin D levels were also higher in males than in females and across all age groups. Average vitamin D levels in all subjects were statistically significant higher in Dammam than Al-Ahsa for 21-40 and >60 years age groups, this difference was even more evident between females in the two cities.

Conclusions: Prevalence of vitamin D deficiency is very high in the current sample of Saudi population. The study also highlights the effects of gender and geographical location on vitamin D levels. This underlines the importance of implementing government programs to increase community awareness of vitamin D deficiency to modify lifestyle and increase sun exposure.
INTRODUCTION

Vitamin D is a vital component of bone health and mineral metabolism [1]. Its other important roles include induction of calcium absorption [2] and reduction of bone loss [3]. Vitamin D deficiency causes skeletal deformities and growth retardation in children and osteomalacia and osteoporosis in adults [1], and contributes to a number of other health problems such as reduced bone mineral density [4] and increased risk of osteoporotic fractures [5]. Some studies suggested that low vitamin D levels could also be associated be with increased risk of cardiovascular diseases [6], and that vitamin D supplementation may reduce the risk of colorectal cancer [7], although further investigations are warranted to confirm these findings.

Vitamin D deficiency is increasingly becoming a worldwide public health problem even in countries with year round sunlight [8]. The problem is even more pronounced in the Middle East, especially among the women and children. In a systematic review, Hilger et al [9] identified numerous studies conducted in 44 countries worldwide on vitamin D status, and more than 37% of the studies reported vitamin D levels of less than 50 nmol/L.

A limited number of studies have been published on the assessment of vitamin D levels in Saudi Arabia. Most of these studies were either conducted in a single city [10], or were restricted to a particular age groups like children [11,12], or in patients suffering from other debilitating conditions [13-15]. Only one study compared vitamin D levels between males and females and between different seasons [16]. None of the studies have compared the results between two geographically distinct regions. In the current study, we report vitamin D levels in subjects in two major cities: the coastal city of Dammam and the inland city of Al-Ahssa in Saudi Arabia. Based on the different lifestyles of the two cities due to their geographical locations, it is expected that people in the coastal city spend more time outdoors, may have higher levels of sunlight exposure, and, therefore, higher levels of vitamin D. The main objective of this study is to determine the effects of gender and geographic residence on blood vitamin D levels. In addition, a number of systematic reviews conducted to describe global vitamin D status pointed to the lack or scarcity of data on vitamin D among vulnerable groups such as infants, children and adolescents. Therefore, our study covered all age groups including infants (in Al-Ahssa) and children (in both cities).

MATERIALS AND METHODS

Study Design and Setting

This is a cross-sectional study that involved analysis of blood samples collected from 2,129 subjects visiting the outpatient clinics in Dammam and Al-Ahssa of eastern province of Saudi Arabia at the Imam Abdulrahman Bin Faisal Hospital and King Abdulaziz Hospital, respectively. Samples were collected in 2011 and 2012.

Sampling Technique and Sample Collection

A simple random sampling technique was employed where patients of both genders and various age groups were selected on different days of the week and at different times of the day. All samples used for the analyses were collected during either the summer or winter seasons to reduce seasonal variations.

Samples were collected in serum separator tubes (SST, BD Diagnostic, NJ, USA), left to be clotted for 30 minutes and then centrifuged to 3000 RPM for 10 minutes. Serum samples were separated, transferred to plastic tubes and shipped frozen to central laboratory of King Abdulaziz Medical City in Riyadh. Upon arrival, serum samples were stored in freezers at temperature of −70°C until the time of analyses. Total 25-Hydroxy Vitamin D levels were analyzed within 2 weeks of collection and run in one batch in each analyzer.

The samples were analyzed by high performance liquid chromatography method (Alliance Waters, Austria). All samples used for the study were checked for hemolysis. The current analysis included 2,129 subjects, of
whom 1,596 (75%) were females and 533 (38%) were males.

**Ethical Considerations**

This study was supported by King Abdullah International Medical Research Center (Protocol: RC0233/09) and approved by the hospitals’ respective Research Ethics Committees. Written informed consent was obtained from all participants or their parents/care-givers in cases of children.

**Statistical Analyses**

Statistical analysis involved a two-tailed t-test (p-values set at 0.05) to determine if there was a significant difference in vitamin D levels between males and females in each city and also between subjects in the two cities. Chi-square test was used to determine the difference between males and females in their distribution in the different categories of vitamin D levels. Categories of vitamin D were divided into: deficient (<25 nmol/L); insufficient (25-50 nmol/L); sufficient (51-75 nmol/L); and optimal (>75 nmol/L).

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**RESULTS**

Table 1 shows age distribution of male and female subjects in Dammam and Al-Ahssa. The proportion of males and females in most age groups was similar in Dammam. However, in Al-Ahssa, 42% of the females were in the 41-60 years age group compared to only 26% of males in the same age category. In Al-Ahssa, there was also a higher proportion (17%) of males younger than 10 compared to only 8% of females.

Table 2 highlights the distribution of subjects in the different categories of vitamin D levels (deficient, insufficient, sufficient, and optimal). The results are striking where about 43% of all subjects in both cities had vitamin D deficiency (less than 25 nmol/L). In Dammam, 46% of females had vitamin D deficiency compared to 32% of males (p value of the difference: <0.0002). In Al-Ahssa, this difference was even more pronounced where 48% of females had vitamin D deficiency compared to 28% of males (p value of the difference: <0.0002). Chi-square (ChSq) test showed statistically significant difference in the proportion of males and females in the different categories of vitamin D in both Dammam (ChSq 0.0165, p <0.05) and Al-Ahssa (ChSq 0.0002, p <0.05). However, there was no significant difference between males of Dammam and males of Al-Ahssa or between females of Dammam and females of Al-Ahssa in their proportional distribution in the different categories of vitamin D (data not shown).

Figure 1 shows vitamin D levels in male and female subjects in Dammam. Generally, males had higher vitamin D levels than females across all age groups, although none of these differences were statistically significant in any age group. In addition, the highest levels of vitamin D were in children younger than 10 years, and a trend of increasing vitamin D levels with increasing age (from 11 years upwards) was noticeable in both males and females.

Figure 2 shows vitamin D levels in Al-Ahssa. Overall, there was a statistically significant difference in vitamin D levels between males and females (p = 0.0002). In all age categories, males had higher levels of vitamin D and the difference was statistically significant in the age group of 11-20 years (p = 0.05). Here too, like in Dammam, vitamin D levels increased with increasing age (from 11 years upwards).
Table 1. Age and Gender Distribution of Study Subjects*

<table>
<thead>
<tr>
<th></th>
<th>Dammam</th>
<th></th>
<th>Al-Ahsaa</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Total</td>
<td>Males</td>
</tr>
<tr>
<td>Number (%)</td>
<td>162 (22)</td>
<td>570 (78)</td>
<td>732</td>
<td>371 (27)</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>42</td>
<td>39</td>
<td>42</td>
<td>41</td>
</tr>
<tr>
<td>Age Groups, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 10</td>
<td>6 (4)</td>
<td>0</td>
<td>6 (0.8)</td>
<td>64 (17)</td>
</tr>
<tr>
<td>11 - 20</td>
<td>15 (9)</td>
<td>36 (7)</td>
<td>51 (7)</td>
<td>35 (9)</td>
</tr>
<tr>
<td>21 - 40</td>
<td>55 (40)</td>
<td>242 (43)</td>
<td>297 (41)</td>
<td>74 (20)</td>
</tr>
<tr>
<td>41 - 60</td>
<td>59 (36)</td>
<td>233 (40)</td>
<td>292 (40)</td>
<td>96 (26)</td>
</tr>
<tr>
<td>≥ 61</td>
<td>27 (17)</td>
<td>59 (10)</td>
<td>86 (12)</td>
<td>102 (27)</td>
</tr>
</tbody>
</table>

* Percentages may not add to 100% due to rounding.

Figure 2. Mean Vitamin D Levels (nmol/L) in Al-Ahsaa

Table 3 compares mean vitamin D levels in subjects from Dammam (the coastal city) and Al-Ahsaa (the inland city). In general, there was no statistically significant difference in mean vitamin D levels between the subjects in the two cities (p = 0.26). In Dammam, however, vitamin D levels were higher across all age groups and this difference was statistically significant only among the subjects in age groups 21-40 years (p = 0.003), and those older than 60 years (p = 0.04). Comparison of vitamin D levels of males from Dammam and those from Al-Ahsaa did not reveal a statistically significant difference (p = 0.53). Overall, females in Dammam had higher levels of vitamin D than those in Al-Ahsaa (p = 0.07). For the subjects in the 21-40 years and >60 years age groups, females in Dammam had statistically significant higher levels of vitamin D than those in Al-Ahsaa (p = 0.0001 and 0.007, respectively).

DISCUSSION

The current study showed high prevalence of vitamin D deficiency among this sample of the Saudi population and the deficiency was more pronounced in the females compared to the males. Living in the coastal city was associated with higher levels of vitamin D especially among the females. Several surveys conducted worldwide showed that vitamin D deficiency is widespread across all age groups and in most regions [17-19]. Limited exposure to sun is an important factor contributing to this deficiency, but it is not the only factor as countries with long winters have less prevalence of vitamin D deficiency [8]. Vitamin D is critical in bone health and has also been linked to a number of conditions that represent major global public health problems; these include hypertension, diabetes, metabolic syndrome, cancer, and autoimmune and infectious diseases [20]. It is, therefore, critical to determine vitamin D levels in the population and then to set out national and regional education programs to increase awareness of the importance of vitamin D for health. Since diet patterns vary in different
### Table 2. Percentage of Subjects in the Different Categories of Vitamin D

<table>
<thead>
<tr>
<th>Vitamin D (nmol/L)</th>
<th>Dammam$^{(1)}$</th>
<th>Al-Ahsaa$^{(2)}$</th>
<th>p-value$^{(3)}$</th>
<th>p-value$^{(3)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (n = 732)</td>
<td>Males (n = 162)</td>
<td>Females (n = 570)</td>
<td>Total (n = 1397)</td>
</tr>
<tr>
<td>Deficient (&lt;25)</td>
<td>43</td>
<td>32</td>
<td>46</td>
<td>0.002</td>
</tr>
<tr>
<td>Insufficient (25-50)</td>
<td>28</td>
<td>34</td>
<td>27</td>
<td>0.12</td>
</tr>
<tr>
<td>Sufficient (51-75)</td>
<td>15</td>
<td>22</td>
<td>13</td>
<td>0.008</td>
</tr>
<tr>
<td>Optimal (&gt;75)</td>
<td>13</td>
<td>12</td>
<td>13</td>
<td>0.7</td>
</tr>
</tbody>
</table>

(1) Overall Chi-Square male to female difference at city level - Dammam: 0.0165, p <0.05
(2) Overall Chi-Square male to female difference at city level - Al-Ahsaa: 0.0002, p <0.05
(3) Difference between males and females for each Vitamin D level category within each city.

### Table 3. Mean Vitamin D Levels (nmol/L) in Dammam (Coastal City) and Al-Ahsaa (Inland City) by Age Groups

<table>
<thead>
<tr>
<th></th>
<th>All Subjects</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dammam</td>
<td>Al-Ahsaa</td>
<td>p-value</td>
</tr>
<tr>
<td>Overall Mean</td>
<td>40</td>
<td>38</td>
<td>0.26</td>
</tr>
<tr>
<td>By Age Groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 10</td>
<td>73</td>
<td>65</td>
<td>0.63</td>
</tr>
<tr>
<td>11 - 20</td>
<td>32</td>
<td>29</td>
<td>0.55</td>
</tr>
<tr>
<td>21 - 40</td>
<td>37</td>
<td>27</td>
<td>0.0003</td>
</tr>
<tr>
<td>41 - 60</td>
<td>40</td>
<td>38</td>
<td>0.32</td>
</tr>
<tr>
<td>≥ 61</td>
<td>53</td>
<td>42</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Vitamin D Status in Saudi Arabia
regions of the world, vitamin D supplementations are necessary to boost the levels. It should then become an important public health practice to make such supplementations readily available and accessible especially for the vulnerable groups including children and women.

Only a few studies have been conducted in the general population in Saudi Arabia to determine levels of vitamin D deficiency [21-24] with all of the studies reporting a very high prevalence of deficiency. Other studies examined vitamin D levels in patients with some medical conditions such as diabetes [25], systemic lupus erythematosus [26], chronic kidney disease [27] and other conditions. The results of these studies showed that vitamin D levels are associated with, and in some cases contribute to, these conditions. The results of the current study showed that more than 42% of the subjects in both cities had vitamin D deficiency according to the categories reported by Wahl et al [19]. This is in accordance with previous studies conducted in Saudi Arabia which also showed high prevalence of vitamin D deficiency or insufficiency. Our results also show that the prevalence of vitamin D deficiency was higher in females than in males. A study in Saudi Arabia also showed similar results of higher levels of deficiency in females compared to males [28]. One study in Saudi females reported vitamin D deficiency in about 79% of subjects [29]. This is not unexpected based on the culture and traditions in Saudi Arabia which are reflected in lifestyle differences between the males and the females, most importantly regarding dress and outdoor activities. Women in the Middle East and Saudi Arabia in particular, are not often exposed to sunlight due to cultural practices that limit their outdoor time and impose dress codes that include covering the whole body in some regions.

The current results show higher levels of vitamin D in Dammam compared to Al-Ahssa in all subjects. This is expected because people of the coastal city of Dammam spend more time outdoors than in the inland city of Al-Ahssa. Still, low vitamin D levels and high prevalence of deficiency in Dammam, especially among females indicates that sun exposure even in this coastal city is inadequate to achieve and maintain optimal vitamin D levels. In accordance with this notion, a recent study showed that subjects residing in the sunny Eastern region in Saudi Arabia have also high levels of vitamin D deficiency despite somewhat adequate sun exposures [30]. Another study in the same region also reported vitamin D deficiency between 28-37% in Saudi male subjects [31]. The difference between females in the two cities was even more evident than the difference between males; most probably because females in Dammam, on average, spend more time outdoors and hence have more sun exposure than females in Al-Ahssa.

Our results show sufficient levels of vitamin D in children, which may be explained by relatively more sun exposure and higher intake of dairy products fortified with vitamin D. A recent study reported much higher level (about 75%) of vitamin D deficiency among children with rickets in Eastern Saudi Arabia [32]. One of the limitations of the current study is that other biomarkers of vitamin D deficiency e.g. parathyroid hormone, calcium, and phosphorus were not measured. Another limitation is the applicability of the current results. The samples in the current study were collected from subjects visiting health care centers for various medical reasons, and it is unknown whether their underlying medical condition may have affected their vitamin D levels. Since no information was collected about their medical background, it would be difficult to ascertain this point. Finally, there was no control of confounding factors such as diet type, exercise, sun light exposure. Diet is a potential confounder as people on the coastal city of Dammam may consume more of sea food rich in vitamin D than residents of the inland city of Al-Ahssa. The major strength of this study is the inclusion of data on infants, children and adolescents in both males and females.

**CONCLUSIONS**

The results are in agreement with previous studies conducted in Saudi Arabia and elsewhere in the world, which showed that vitamin D deficiency is a widespread problem. Cultural and traditional values in Saudi Arabia affect mainly women’s dress and outdoor activity resulting in low sun exposure. Furthermore, the study of Christie and Mason [33] reported a limited knowledge about vitamin D importance
and deficiency among female Saudi participants. This calls for immediate action to promote awareness and education and to embark on a national program to provide vitamin D supplementation to the Saudi population in all age groups.

**AUTHORS’ CONTRIBUTIONS**

Mustafa Al-Zoughool conceived and carried out the main analyses, drafted and edited the manuscript. Ali Alshehri participated in the coordination of the study and wrote sections of the manuscript; Ali Alqarni participated in the study design; Ahmed Alarfaj contributed to the conception of the original study. Waleed Tamimi participated in the study design and data analysis and coordination, and edited the manuscript. All authors have read and approved the final manuscript.

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**CONFLICT OF INTEREST**

Authors have declared that no competing interests exist.

**REFERENCES**