ARTICLE INFO

Key Words:
Hypovitaminosis D, Body Mass Index (BMI), Tukey HSD Means Separation Test

How to Cite:

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Received Date: 2nd October, 2023
Acceptance Date: 29th December, 2023
Published Date: 31st December, 2023

INTRODUCTION

Vitamin D deficiency is a considerable public health concern affecting predominantly South Asians, including Pakistan, affecting ~85% of the population [1, 2]. More than 90% of vitamin D is synthesized as cholecalciferol (D3) on skin exposure to solar ultraviolet (UV) B radiation. It is primarily responsible for calcium and phosphate homeostasis, which regulates bone metabolism [3]. Hypovitaminosis D can lead to osteomalacia, rickets, osteoporosis, and an increased risk of fracture [4]. Moreover, it has several extra skeletal functions, evidenced by the association of hypovitaminosis D with several diseases, including diabetes mellitus, inflammatory, and cardiovascular disorders [5]. Recent research has also linked hypovitaminosis D to an increased coronavirus disease-19 (COVID-19) risk [6]. The vitamin D status in an individual depends on seasonal variations, low UV intensity regions, duration of UV exposure, age, gender, obesity, lack of physical activity, occupation, skin complexion, diet, and increased requirements (pregnancy and lactation). Its production does not occur regularly owing to inadequate...
solar exposure and dietary intake, predisposing the population to vitamin D deficiency [5, 7]. Previous research has shown a high prevalence of vitamin D deficiency among females in Pakistan; however, there is a scarcity of statistics reporting variations in vitamin D levels among females related to occupational groups [8].

In the current study, serum 25(OH)D was determined and compared in four occupations: outdoor workers, who had the most exposure to sunlight; university students and office workers, who were moderately exposed; and housewives, who were relatively less exposed.

M ETHO DS
A comparative cross-sectional study between 2016 and 2018 at the Physiology Department, Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro, was performed. Samples were collected during summer, i.e., from April to July. In this study, n = 236 females were recruited by non-probability consecutive sampling technique into four groups based on the level of sun exposure: Group A consisted of 59 outdoor workers (laborers, beggars, daily wagers); Group B consisted of 59 office workers; Group C consisted of 59 students; and Group D consisted of 59 housewives. The sample size of n = 236 was calculated from the findings that 85–98% of people in our region had lower vitamin D (<30 ng/mL) in previous studies [9]. Data on socio-demographic variables were obtained directly from participants on a pre-designed proforma. Sun exposure was defined as the exposure of participants to direct sunlight through the exposure of a minimum of 20% of the body involving the arms, hands and face [10]. Body mass index (BMI) was classified as per Asian and South Asian classification [11]. Adult females, residents of Sindh, Pakistan, between 18 and 40 years of age according to the selected occupations, were recruited. Medical history and investigations were evaluated and clinical examination performed. Women who had a history of osteoporosis or medical disorders including hepatic or renal disease, metabolic bone disorders, hormonal disorders, diabetes mellitus malabsorption, and malignancy, taking lipid-lowering drugs, supplements, or medicines that affect vitamin D levels, pregnant and lactating women were excluded. This project was approved by the Ethical Review Committee of Liaquat University of Medical and Health Sciences, Jamshoro (Reference No. LUMHS/REC/339). After written informed consent, participants’ venous blood (5 mL) was collected from the antecubital vein under aseptic conditions. The serum vitamin D was measured by the Architect (Abbott Diagnostics, Lake Forest, IL, USA) 25(OH)D assay (product 3L52). Vitamin D deficiency was defined as 25 hydroxyvitamin D (25(OH)D) level < 20 ng/mL, insufficiency as ≥20 to 29.9 ng/mL, while 25(OH) D ≥30 ng/mL was considered as sufficient [9]. For data analysis SPSS v.23 and MedCalc software were used. The p-value ≤ 0.05 was considered significant. The mean and standard deviation (SD) for continuous variables were computed and a one-way analysis of variance (ANOVA) test was performed on mean vitamin D levels for comparing >2 parametric groups with a Tukey HSD means separation test. The odds ratio (OR) and 95% confidence interval (CI) were calculated for categorical variables in bivariate analysis i.e, BMI, type of dressing and daily intake of Vitamin D enriched foods.

R ESUL TS
The mean age ± SD was 31.6±5.26 years. Table 1 shows socio-demographic variables. The mean serum 25 (OH)D concentration was 21.5±7.13 ng/mL (range = 3.7-60).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Outdoor workers (n=59)</th>
<th>Office workers (n=59)</th>
<th>Students (n=59)</th>
<th>Housewives (n=59)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>18–23</td>
<td>10</td>
<td>07</td>
<td>28</td>
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<tr>
<td></td>
<td>24–29</td>
<td>01</td>
<td>01</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>30–35</td>
<td>22</td>
<td>40</td>
<td>05</td>
</tr>
<tr>
<td></td>
<td>36–40</td>
<td>26</td>
<td>11</td>
<td>02</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
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<td>31</td>
<td>51</td>
<td>0</td>
</tr>
<tr>
<td>Married</td>
<td>26</td>
<td>28</td>
<td>08</td>
<td>59</td>
</tr>
<tr>
<td>Level of Education</td>
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<tr>
<td>Illiterate</td>
<td>59</td>
<td>0</td>
<td>0</td>
<td>02</td>
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<tr>
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<td>25</td>
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<td>07</td>
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<td>44</td>
<td>51</td>
</tr>
<tr>
<td>graduation &amp; more</td>
<td></td>
<td></td>
<td></td>
<td>03</td>
</tr>
<tr>
<td>Family Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50,000 Rupees/month</td>
<td>59</td>
<td>30</td>
<td>31</td>
<td>19</td>
</tr>
<tr>
<td>(&gt;220 USD /month)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>&gt;50,000 Rupees/month</td>
<td>0</td>
<td>29</td>
<td>28</td>
<td>40</td>
</tr>
<tr>
<td>(&gt;220 USD /month)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A total of 103 (43.6%) were deficient and 68 (28.9%) had insufficient vitamin D levels. Figure 1 shows vitamin D status among different occupations in female categories.
The majority of the females (50.5%) had normal weight, whereas 23.7% were overweight and 22% were obese. Deficiency of vitamin D increased more than 3-fold (P = 0.002) in the overweight group, whereas obesity increased the risk of deficiency by more than 4-fold (P = 0.0009) (Table 4). No association was noted between vitamin D status and dressing type or diet.

**Table 4**: Bivariate analysis showing unadjusted odds ratio and 95% CI between body mass index, type of dressing and intake of vitamin D enriched diet with vitamin D status in females

Body mass index (BMI); CI: Confidence interval; OR: Odds ratio

*Deficient and insufficient categories are combined for analysis

**DISCUSSION**

Hypovitaminosis D is a challenging problem globally and despite Pakistan’s location in the sun belt it is highly prevalent, which is attributed to less sun exposure and lifestyle changes [12-14]. Though previous studies have documented vitamin D status in Pakistan, our study has added a distinct criterion to identify the occupational-related association of vitamin D status among females of Sindh, Pakistan [15]. Due to the fact that the present investigation was done during the summer, the vitamin D levels detected in this study possibly denote the greatest seasonal levels. The annual sun graphs for Hyderabad and Jamshoro cities in Sindh Province are shown in Figure 2.
We observed the high prevalence of vitamin D insufficiency and deficiency (72.5%) among healthy adult females related to different occupations living in Sindh, Pakistan. Another study reported 74.7% of the Rawalpindi and Islamabad residents of Pakistan as vitamin D deficient, with females contributing 79.7% [16]. Avoidance of sun exposure, diet, and lower calcium intake were the main factors associated with it [17, 18]. Vitamin D has a crucial role in females, since its inadequacy might have adverse health effects in addition to affecting prenatal and postnatal growth [19]. The present study has shown significant differences in vitamin D levels among outdoor workers, office workers, students, and housewives. Previous studies have identified the high prevalence of vitamin D deficiency in office workers and housewives, as the majority of them are restricted to indoors or in offices with insufficient exposure to sunlight, that coincides with present study findings [20]. Occupational related sun exposure is associated with higher vitamin D levels. Outdoor employees had 4-8 times higher 25(OH)D levels than their indoor counterparts [21]. In a recent Korean research, wage earners who worked outdoor had greater 25(OH)D levels than indoor workers [22]. Another Korean study showed higher 25(OH)D levels in fisherman (23.74 ± 8.88 ng/mL) who have highest sunlight exposure compared to the general occupational group (13.60 ± 6.43 ng/mL) [23]. Sowah et al., in systemic review reported that, indoor workers had lower vitamin D levels (40.6 ± 13.3 vs. 66.7 ± 16.7 nmol/L; p < 0.0001) compared to outdoor workers. The prevalence of vitamin D deficiency was higher among shift workers (80%) and indoor workers (78%) in contrast to outdoor workers (48%). Within the healthcare professionals, residents and students exhibited the lowest levels at 44.0 ± 8.3 nmol/L and 45.2 ± 5.5 nmol/L, respectively. Similar to these findings, we also found that across all examined groups, there were markedly high rates of vitamin D deficiency or insufficiency [24]. We found that females with minimum sunlight contact were at an increased risk for vitamin D deficiency. Avoiding sun exposure is a frequent practice in Pakistan, particularly among females. This is due to various factors, including modern and sedentary lifestyles; hot climates; fairer skin obsession with the preferred use of sunscreen and religious and cultural aspects in the dressing of women to cover the entire body [18, 25, 26]. A national strategy must be developed due to the significant prevalence of hypovitaminosis D in the Pakistani population, particularly among females. Accessibility of vitamin D supplements at the primary health care for high-risk group (pregnant women, breast-feeding mothers, children, and adults), raising public awareness and community education for the prevention of vitamin D deficiency by adjusting appropriate lifestyle practices, sufficient sun exposure, and increasing dietary vitamin D fortified foods must be an important goal of this strategy [27]. Our research has a number of limitations. It is a cross-sectional study. Due to the small sample sizes in individual occupational categories, the body mass index, type of clothing, and dietary vitamin D intake could not be analyzed by occupational group. As our primary objective was to analyze vitamin D concentrations in females in relation to different occupations, we did not include males in our study. However, future research is required to address these gaps.

CONCLUSIONS
The study results suggested that, there is high prevalence of vitamin D deficiency in females of Sindh, Pakistan. The study indicated that females with less sun exposure were at greater risk of developing vitamin D deficiency.

Authors Contribution
Conceptualization: KR
Methodology: KR, HR
Formal analysis: KR, FFK, SL, HL, AHK
Writing-review and editing: FFK, HR, SL, HL, AHK
All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest
The authors declare no conflict of interest.

Source of Funding
The authors received no financial support for the research, authorship and/or publication of this article.

REFERENCES


