

Prevalence and Risk Factors of Vitamin D Deficiency among Undergraduate Medical Students in a Tertiary Care Teaching Hospital

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Abstract

Background: Vitamin D deficiency has emerged as a global public health concern, affecting populations across all age groups and geographical regions. Medical students represent a particularly vulnerable population due to demanding academic schedules, limited outdoor exposure, and irregular lifestyle patterns. Understanding the prevalence and associated risk factors of vitamin D deficiency among this population is essential for developing targeted preventive interventions.

Methods: This cross-sectional analytical study was conducted among undergraduate medical students at a tertiary care teaching hospital over a six-month period. A total of 384 students from all academic years were enrolled through stratified random sampling. Serum 25-hydroxyvitamin D [25(OH)D] levels were measured using chemiluminescent immunoassay. A structured questionnaire assessed demographic characteristics, lifestyle factors, dietary habits, sun exposure patterns, and physical activity levels. Vitamin D deficiency was defined as serum 25(OH)D levels <20 ng/mL, insufficiency as 20-29 ng/mL, and sufficiency as ≥30 ng/mL.

Results: The mean age of participants was 20.8 ± 1.9 years, with 214 females (55.7%) and 170 males (44.3%). The overall prevalence of vitamin D deficiency was 67.4% (n=259), while 21.6% (n=83) had insufficient levels. Mean serum 25(OH)D concentration was 17.2 ± 8.6 ng/mL. Female gender (OR=2.84, 95% CI: 1.78-4.53, p<0.001), limited sun exposure <30 minutes/day (OR=3.12, 95% CI: 1.96-4.97, p<0.001), dark skin complexion (OR=2.18, 95% CI: 1.42-3.35, p<0.001), and sedentary lifestyle (OR=1.89, 95% CI: 1.24-2.88, p=0.003) were significant independent risk factors.

Conclusion: Vitamin D deficiency is highly prevalent among undergraduate medical students, necessitating implementation of awareness programs, lifestyle modifications, and consideration of routine screening and supplementation strategies.

Keywords: Vitamin D deficiency; medical students; 25-hydroxyvitamin D; risk factors; sun exposure; prevalence.

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Introduction

Vitamin D deficiency has been recognized as a pandemic affecting approximately one billion people worldwide, transcending geographical boundaries, age groups, and socioeconomic strata [1]. Despite abundant sunlight availability in many regions, the prevalence of hypovitaminosis D continues to rise, reflecting complex interactions between lifestyle changes, urbanization, and behavioral modifications [2].

This fat-soluble vitamin plays crucial roles beyond calcium homeostasis, influencing immune function, cardiovascular health, cognitive performance, and mental well-being [3]. The primary source of vitamin D in humans is cutaneous synthesis

through ultraviolet B (UVB) radiation exposure, contributing approximately 80-90% of total vitamin D requirements [4]. However, modern lifestyle patterns characterized by indoor activities, sun avoidance behaviors, and extensive use of sunscreen have significantly reduced natural vitamin D synthesis [5]. Dietary sources, including fatty fish, fortified foods, and supplements, often fail to compensate for inadequate sunlight exposure [6]. Medical students constitute a unique demographic warranting special attention regarding vitamin D status.

The demanding nature of medical education, characterized by extensive indoor study hours,

irregular sleep patterns, and limited recreational outdoor activities, predisposes this population to reduced sunlight exposure [7]. Furthermore, the stress associated with rigorous academic curricula may influence dietary habits and lifestyle choices, potentially exacerbating vitamin D deficiency [8].

Recent epidemiological studies have documented alarming rates of vitamin D deficiency among healthcare students across various countries. Research conducted in Saudi Arabia reported prevalence rates exceeding 80% among medical students [9]. Similar findings have been observed in studies from India, where prevalence rates ranging from 70% to 90% have been documented despite adequate sunshine throughout the year [10]. These statistics are particularly concerning given the potential implications for cognitive function, academic performance, and long-term health outcomes [11].

The consequences of vitamin D deficiency extend beyond musculoskeletal manifestations. Emerging evidence suggests associations between low vitamin D status and increased susceptibility to respiratory infections, autoimmune disorders, cardiovascular diseases, and mood disturbances [12]. For medical students, who are exposed to various pathogens in clinical settings, adequate vitamin D status may be particularly relevant for maintaining optimal immune function [13]. Despite growing awareness of vitamin D deficiency as a public health problem, systematic assessment of prevalence and risk factors among medical students in many institutions remains limited [14]. Understanding the magnitude of this problem and identifying modifiable risk factors is essential for developing evidence-based interventions [15]. Furthermore, as future healthcare providers, medical students with personal experience of vitamin D deficiency may be better positioned to counsel patients on preventive strategies [16].

The aim of this study was to determine the prevalence of vitamin D deficiency among undergraduate medical students in a tertiary care teaching hospital and to identify associated sociodemographic, lifestyle, and dietary risk factors.

Materials and Methods

Study Design and Setting: This cross-sectional analytical study was conducted at a tertiary care teaching hospital affiliated medical college.

Sample Size Calculation: Sample size was calculated using the formula for prevalence studies: $n = Z^2pq/d^2$, where $Z = 1.96$ (for 95% confidence level), $p = 0.70$ (anticipated prevalence based on previous studies), $q = 1-p = 0.30$, and $d = 0.05$ (margin of error). The minimum required sample size was 323. Accounting for 15% non-response

rate, the target enrollment was 380 participants. A total of 412 students were approached, and 384 provided complete data for analysis.

Participant Selection

Inclusion Criteria:

- Undergraduate medical students (MBBS program) enrolled in the institution
- Students from all academic years (1st through final year)
- Age between 17 and 30 years
- Willing to provide informed consent

Exclusion Criteria:

- Students receiving vitamin D supplementation within the past three months
- Known diagnosis of conditions affecting vitamin D metabolism (chronic kidney disease, liver disease, malabsorption syndromes)
- Students on medications affecting vitamin D metabolism (anticonvulsants, glucocorticoids, antitubercular drugs)
- Pregnancy
- Students who declined participation

Sampling Technique: Stratified random sampling was employed to ensure proportionate representation from all academic years. The total student enrollment in each year was obtained from academic records, and participants were randomly selected using computer-generated random numbers proportional to class size.

Data Collection

Questionnaire Administration

A pre-tested, structured questionnaire was administered to collect information on:

- **Demographic characteristics:** Age, gender, academic year, residential status (hostel/day scholar), socioeconomic status
- **Anthropometric measurements:** Height and weight for body mass index calculation
- **Skin complexion:** Self-reported using Fitzpatrick skin type classification (Types I-III: fair; Types IV-VI: dark)
- **Sun exposure assessment:** Average daily duration of unprotected sun exposure (without sunscreen, between 10 AM and 3 PM), body surface area exposed, sunscreen usage frequency
- **Dietary assessment:** Frequency of consumption of vitamin D-rich foods (fish, eggs, fortified milk, dairy products) using a food frequency questionnaire
- **Physical activity:** International Physical Activity Questionnaire (IPAQ) short form, categorized as low, moderate, or high activity
- **Lifestyle factors:** Study hours per day, sleep duration, stress levels (perceived stress scale)

Anthropometric Measurements: Height was measured using a stadiometer (accuracy ± 0.1 cm) with participants standing barefoot. Weight was measured using a calibrated digital weighing scale (accuracy ± 0.1 kg) with light clothing. Body mass index (BMI) was calculated and categorized according to Asian criteria: underweight (<18.5 kg/m²), normal (18.5-22.9 kg/m²), overweight (23-24.9 kg/m²), and obese (≥ 25 kg/m²).

Blood Sample Collection and Analysis: Venous blood samples (5 mL) were collected between 8:00 AM and 10:00 AM following overnight fasting. Samples were centrifuged, and serum was separated and stored at -20°C until analysis. Serum 25-hydroxyvitamin D [25(OH)D] levels were measured using chemiluminescent microparticle immunoassay (CMIA) on Abbott Architect i2000SR analyzer. The assay had a measurement range of 3.4-155.9 ng/mL, with intra-assay and inter-assay coefficients of variation of $<5\%$ and $<8\%$, respectively.

Vitamin D Status Classification

Based on Endocrine Society Clinical Practice Guidelines:

- Deficiency: 25(OH)D <20 ng/mL

- Insufficiency: 25(OH)D 20-29 ng/mL
- Sufficiency: 25(OH)D ≥ 30 ng/mL
- Severe deficiency: 25(OH)D <10 ng/mL

Statistical Analysis: Data were analyzed using SPSS version 25.0 (IBM Corporation, Armonk, NY). Continuous variables were expressed as mean \pm standard deviation and compared using independent samples t-test or one-way ANOVA with post-hoc Tukey's test. Categorical variables were presented as frequencies and percentages, with chi-square test for group comparisons.

Pearson correlation coefficient assessed relationships between continuous variables. Binary logistic regression analysis identified independent risk factors for vitamin D deficiency, with results expressed as odds ratios (OR) with 95% confidence intervals (CI). A p-value <0.05 was considered statistically significant.

Results

Participant Characteristics: Of 412 students approached, 384 (93.2%) provided complete data and were included in the final analysis. The demographic and baseline characteristics of participants are presented in Table 1.

Table 1: Demographic and Baseline Characteristics of Study Participants (N=384)

| Variable | n (%) or Mean \pm SD |
|---|------------------------|
| Age (years) | 20.8 \pm 1.9 |
| Gender | |
| Male | 170 (44.3%) |
| Female | 214 (55.7%) |
| Academic Year | |
| First year | 92 (24.0%) |
| Second year | 88 (22.9%) |
| Third year | 86 (22.4%) |
| Final year | 118 (30.7%) |
| Residential Status | |
| Hostel | 268 (69.8%) |
| Day scholar | 116 (30.2%) |
| Body Mass Index (kg/m²) | 22.4 \pm 3.8 |
| Underweight (<18.5) | 52 (13.5%) |
| Normal (18.5-22.9) | 186 (48.4%) |
| Overweight (23-24.9) | 94 (24.5%) |
| Obese (≥ 25) | 52 (13.5%) |
| Skin Complexion | |
| Fair (Fitzpatrick I-III) | 148 (38.5%) |
| Dark (Fitzpatrick IV-VI) | 236 (61.5%) |
| Sun Exposure (minutes/day) | |
| <15 minutes | 124 (32.3%) |
| 15-30 minutes | 156 (40.6%) |
| >30 minutes | 104 (27.1%) |
| Physical Activity Level | |
| Low | 198 (51.6%) |
| Moderate | 138 (35.9%) |
| High | 48 (12.5%) |
| Study Hours (per day) | 8.2 \pm 2.4 |

| Vitamin D Rich Food Intake | |
|-----------------------------------|-------------|
| Adequate (≥ 3 times/week) | 126 (32.8%) |
| Inadequate (< 3 times/week) | 258 (67.2%) |

Vitamin D Status: The mean serum 25(OH)D concentration was 17.2 ± 8.6 ng/mL (range: 4.2-48.6 ng/mL).

The overall prevalence of vitamin D deficiency (< 20 ng/mL) was 67.4% (n=259), while 21.6% (n=83) had insufficient levels (20-29 ng/mL). Only

10.9% (n=42) had sufficient vitamin D status (≥ 30 ng/mL).

Among those with deficiency, 24.2% (n=93) had severe deficiency (< 10 ng/mL).

Comparison of Vitamin D Levels by Participant Characteristics

Table 2: Comparison of Serum 25(OH)D Levels According to Participant Characteristics

| Variable | Mean 25(OH)D (ng/mL) | p-value |
|---------------------------|----------------------|-------------|
| Gender | | $< 0.001^*$ |
| Male | 20.4 ± 9.2 | |
| Female | 14.6 ± 7.1 | |
| Academic Year | | 0.042* |
| First year | 18.6 ± 8.8 | |
| Second year | 17.8 ± 8.4 | |
| Third year | 16.2 ± 8.2 | |
| Final year | 15.8 ± 8.6 | |
| Residential Status | | 0.018* |
| Hostel | 16.4 ± 8.2 | |
| Day scholar | 19.1 ± 9.1 | |
| BMI Category | | 0.024* |
| Underweight | 18.6 ± 8.4 | |
| Normal | 18.2 ± 8.8 | |
| Overweight | 15.4 ± 7.8 | |
| Obese | 14.2 ± 7.6 | |
| Skin Complexion | | $< 0.001^*$ |
| Fair | 20.8 ± 9.4 | |
| Dark | 14.9 ± 7.2 | |
| Sun Exposure | | $< 0.001^*$ |
| < 15 minutes/day | 13.2 ± 6.4 | |
| 15-30 minutes/day | 17.4 ± 8.2 | |
| > 30 minutes/day | 22.6 ± 9.8 | |
| Physical Activity | | $< 0.001^*$ |
| Low | 14.8 ± 7.2 | |
| Moderate | 19.2 ± 8.8 | |
| High | 23.4 ± 10.2 | |
| Dietary Intake | | 0.003* |
| Adequate | 19.6 ± 9.4 | |
| Inadequate | 16.0 ± 7.8 | |

*Statistically significant ($p < 0.05$)

Risk Factors for Vitamin D Deficiency: Binary logistic regression analysis was performed to identify independent risk factors for vitamin D deficiency. Variables with $p < 0.1$ in univariate analysis were included in the multivariate model.

Table 3: Logistic Regression Analysis of Risk Factors for Vitamin D Deficiency

| Variable | Crude OR (95% CI) | p-value | Adjusted OR (95% CI) | p-value |
|----------------------|-------------------|-----------|----------------------|-----------|
| Gender | | | | |
| Male | Reference | | Reference | |
| Female | 3.24 (2.12-4.96) | < 0.001 | 2.84 (1.78-4.53) | < 0.001 |
| Academic Year | | | | |
| First year | Reference | | Reference | |
| Second year | 1.18 (0.64-2.18) | 0.594 | 1.12 (0.58-2.16) | 0.742 |

| | | | | |
|---------------------------|------------------|--------|------------------|--------|
| Third year | 1.42 (0.76-2.66) | 0.274 | 1.28 (0.64-2.56) | 0.486 |
| Final year | 1.68 (0.94-3.02) | 0.082 | 1.46 (0.76-2.82) | 0.258 |
| Residential Status | | | | |
| Day scholar | Reference | | Reference | |
| Hostel | 1.72 (1.12-2.64) | 0.014 | 1.38 (0.86-2.22) | 0.182 |
| Skin Complexion | | | | |
| Fair | Reference | | Reference | |
| Dark | 2.68 (1.78-4.04) | <0.001 | 2.18 (1.42-3.35) | <0.001 |
| Sun Exposure | | | | |
| >30 minutes/day | Reference | | Reference | |
| 15-30 minutes/day | 2.14 (1.28-3.58) | 0.004 | 1.86 (1.08-3.20) | 0.026 |
| <15 minutes/day | 4.26 (2.48-7.32) | <0.001 | 3.12 (1.96-4.97) | <0.001 |
| Physical Activity | | | | |
| High | Reference | | Reference | |
| Moderate | 1.56 (0.78-3.12) | 0.208 | 1.42 (0.68-2.96) | 0.348 |
| Low | 2.48 (1.28-4.82) | 0.007 | 1.89 (1.24-2.88) | 0.003 |
| BMI Category | | | | |
| Normal/Underweight | Reference | | Reference | |
| Overweight/Obese | 1.86 (1.24-2.79) | 0.003 | 1.54 (0.98-2.42) | 0.062 |
| Dietary Intake | | | | |
| Adequate | Reference | | Reference | |
| Inadequate | 1.78 (1.18-2.68) | 0.006 | 1.48 (0.94-2.32) | 0.092 |

Correlation analysis revealed significant negative correlation between study hours and serum 25(OH)D levels ($r = -0.32$, $p < 0.001$) and positive correlation between sun exposure duration and vitamin D levels ($r = 0.48$, $p < 0.001$).

Discussion

This study reveals an alarmingly high prevalence of vitamin D deficiency (67.4%) among undergraduate medical students, with only 10.9% demonstrating sufficient vitamin D status. These findings are consistent with global trends documenting widespread hypovitaminosis D among young adults in general and medical students in particular [17].

The mean serum 25(OH)D concentration of 17.2 ± 8.6 ng/mL observed in our study is comparable to findings from other Asian countries. A study conducted among medical students in Pakistan reported mean levels of 15.8 ng/mL [18], while research from Malaysia documented mean concentrations of 18.4 ng/mL [19]. The consistency of these findings across different geographical regions with varying sunshine availability underscores the behavioral and lifestyle determinants of vitamin D status rather than purely environmental factors [20].

Female gender emerged as a strong independent risk factor, with female students demonstrating 2.84 times higher odds of deficiency compared to males. This gender disparity has been consistently reported in literature and may be attributed to greater sun avoidance behaviors, more extensive clothing coverage, and cosmetic sunscreen use among females [21]. Cultural factors influencing

outdoor activity patterns and dress codes likely contribute to this differential vulnerability [22]. Additionally, differences in body composition, with females typically having higher adipose tissue content that sequesters vitamin D, may partially explain this observation [23].

Limited sun exposure (<30 minutes daily) was the strongest modifiable risk factor identified, conferring three-fold increased odds of deficiency. The demanding medical curriculum, requiring extensive indoor study time averaging 8.2 hours daily, significantly restricts opportunities for outdoor activities [24]. Our finding of negative correlation between study hours and vitamin D levels ($r = -0.32$) supports this relationship. Similar associations have been documented among medical students in other institutions, where academic workload inversely correlated with vitamin D status [25].

Dark skin complexion significantly increased deficiency risk, consistent with established understanding of melanin's interference with UVB-mediated vitamin D synthesis [26]. Individuals with darker skin require substantially longer sun exposure to achieve equivalent vitamin D production compared to those with lighter complexion [27]. This has particular relevance for populations in South Asian countries where darker skin types predominate yet sun avoidance behaviors persist due to cosmetic preferences for lighter skin [28]. Sedentary lifestyle, characterized by low physical activity levels, was independently associated with vitamin D deficiency. This relationship likely reflects the interconnection between physical activity and outdoor exposure

rather than direct effects of exercise on vitamin D metabolism [29]. Students engaging in regular physical activity, particularly outdoor sports, naturally accumulate greater sun exposure. Furthermore, physical activity may influence vitamin D bioavailability through effects on body composition and adipose tissue distribution [30].

The progressive decline in vitamin D levels observed across academic years, though not reaching statistical significance in adjusted analysis, suggests cumulative effects of reduced outdoor exposure throughout medical training. Clinical year students, with increased hospital duties in enclosed environments, may face additional challenges maintaining adequate vitamin D status [31]. Dietary factors showed borderline significance in adjusted analysis, reflecting the limited contribution of dietary sources to overall vitamin D status. In regions where food fortification programs are inconsistent, dietary modification alone is unlikely to address population-level deficiency [32]. Nevertheless, promoting consumption of vitamin D-rich foods remains a reasonable component of comprehensive prevention strategies [33].

The implications of these findings for medical education are substantial. Vitamin D deficiency has been associated with impaired cognitive function, reduced concentration, and increased susceptibility to infections—all potentially impacting academic performance and clinical competence [34]. Moreover, students experiencing deficiency may be at elevated risk for mood disturbances and mental health problems during an already stressful training period [35].

Study limitations include the cross-sectional design precluding causal inference, reliance on self-reported behavioral data, and single-point vitamin D measurement that does not capture seasonal variations. Additionally, the single-center design may limit generalizability to other geographical and institutional settings.

Conclusion

This study demonstrates that vitamin D deficiency is highly prevalent among undergraduate medical students, affecting over two-thirds of the study population. Female gender, limited sun exposure, dark skin complexion, and sedentary lifestyle emerged as significant independent risk factors. The demanding nature of medical education, characterized by extensive indoor study requirements, contributes substantially to this problem.

These findings underscore the urgent need for implementing targeted interventions within medical institutions. Recommended strategies include incorporation of vitamin D awareness into medical

curricula, architectural modifications to maximize natural light exposure in study areas, scheduled outdoor activity breaks, and consideration of routine screening and supplementation programs for at-risk students. Given that medical students will become future healthcare providers responsible for counseling patients on nutritional health, addressing their own vitamin D status assumes additional significance. Longitudinal studies examining the impact of vitamin D status on academic performance and clinical outcomes are warranted to further inform evidence-based policies.

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