

## **“A Clinical Study on the Pattern of Vitamin D Deficiency and Its Association with Metabolic and Musculoskeletal Disorders in Adults Attending a Tertiary Care Hospital in North India”**

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### **Abstract**

*Vitamin D deficiency (VDD) has emerged as a global health concern, particularly in developing nations like India, where sunlight is abundant but lifestyle and dietary patterns contribute to widespread deficiency. The present cross-sectional hospital-based study was conducted in 2015 in the Department of General Medicine, Santosh Medical College & Hospital, Ghaziabad, to evaluate the prevalence of Vitamin D deficiency and its association with metabolic and musculoskeletal disorders among adult patients. A total of 280 patients aged 18–70 years were included. Serum 25-hydroxyvitamin D [25(OH)D] levels were estimated using chemiluminescence immunoassay. Values <20 ng/mL were defined as deficient, 20–30 ng/mL as insufficient, and >30 ng/mL as sufficient. Clinical history, biochemical parameters, and musculoskeletal symptoms were recorded. The study revealed that 71.4% of subjects had Vitamin D deficiency, while 18.2% were insufficient and only 10.4% had sufficient levels. Deficiency was more prevalent among females (76%) and sedentary individuals (81%). The most common clinical manifestations were generalized fatigue (64%), musculoskeletal pain (58%), and proximal muscle weakness (41%). Vitamin D deficiency showed a significant association with elevated fasting glucose, high BMI, and dyslipidemia ( $p < 0.05$ ). These findings highlight that Vitamin D deficiency is highly prevalent even among apparently healthy adults in North India and is linked not only to skeletal problems but also to metabolic abnormalities. Routine screening, dietary supplementation, and lifestyle modifications are recommended to prevent the long-term complications of Vitamin D deficiency in the Indian population.*

**Keywords:** *Vitamin D deficiency, Metabolic Syndrome, Musculoskeletal Pain, Serum 25(OH)D, North India, Adults, Dyslipidemia*

### **Introduction**

Vitamin D is a fat-soluble secosteroid hormone that plays an essential role in calcium and phosphorus metabolism, bone mineralization, and overall musculoskeletal health. In recent years, its role has expanded beyond bone physiology to include immune regulation, insulin sensitivity, cardiovascular health, and cancer prevention [1]. Despite India's geographical advantage of abundant sunlight, Vitamin D deficiency (VDD) has reached alarming proportions across all age groups and socioeconomic strata. The deficiency is primarily attributed to urbanization, limited

outdoor activity, dietary insufficiency, and increasing air pollution that reduces ultraviolet B (UVB) exposure [2,3].

Vitamin D exists in two major forms—D<sub>2</sub> (ergocalciferol) and D<sub>3</sub> (cholecalciferol). The latter is synthesized endogenously in the skin upon exposure to sunlight, accounting for nearly 90% of the body's requirement [4]. It is metabolized in the liver to 25-hydroxyvitamin D [25(OH)D], the major circulating form, and subsequently hydroxylated in the kidney to 1,25-dihydroxyvitamin D, the biologically active form. Serum 25(OH)D is considered the best indicator of Vitamin D status [5]. Deficiency of Vitamin D results in impaired calcium absorption, secondary hyperparathyroidism, and bone resorption, leading to osteomalacia in adults. However, recent research indicates that low Vitamin D levels are also linked to several non-skeletal disorders, including obesity, insulin resistance, type 2 diabetes, hypertension, dyslipidemia, and autoimmune diseases [6,7]. The widespread expression of Vitamin D receptors (VDRs) in various tissues such as the pancreas, vascular endothelium, and immune cells supports its pleiotropic role in human physiology [8].

In India, despite high sunshine availability, the prevalence of Vitamin D deficiency is reported to range from **70% to 90%** in various studies, depending on geographical region and study population [9]. Factors contributing to this paradox include darker skin pigmentation, traditional clothing, cultural practices limiting sun exposure, and low intake of Vitamin D-fortified foods [10]. Urban populations, especially professionals and homemakers, are at higher risk due to indoor lifestyles and pollution-related attenuation of UVB rays. The growing recognition of Vitamin D's extra-skeletal functions has raised concern about its potential contribution to metabolic syndrome and cardiovascular risk factors [11]. Several studies have shown an inverse association between serum 25(OH)D levels and markers of insulin resistance, lipid abnormalities, and systemic inflammation [12]. Moreover, deficiency often coexists with musculoskeletal symptoms such as fatigue, diffuse bone pain, and proximal muscle weakness, which are frequently misdiagnosed or overlooked in routine clinical practice.

Given these considerations, this study was designed to assess the **pattern and prevalence of Vitamin D deficiency** and to evaluate its **association with metabolic and musculoskeletal disorders** in adult patients attending a tertiary care hospital in North India. By establishing local data, this research aims to enhance clinical awareness, encourage early screening, and support the integration of Vitamin D assessment into routine metabolic evaluations in general medicine practice.

## Materials and Methods

### *Study Design and Setting*

This was a **cross-sectional, observational study** conducted in the **Department of General Medicine**, Santosh Medical College & Hospital, Ghaziabad, Uttar Pradesh, from **January to December 2015**. The study aimed to determine the prevalence of Vitamin D deficiency (VDD)

and its correlation with metabolic and musculoskeletal disorders in adults attending outpatient and inpatient departments.

### *Study Population*

A total of **280 adult patients** (aged 18–70 years) were enrolled after obtaining informed written consent. Both male and female subjects from diverse socioeconomic backgrounds were included. The sample size was calculated based on the estimated 70% prevalence of VDD in India with a 95% confidence interval and 5% margin of error [1].

### *Inclusion Criteria*

1. Adults aged between 18 and 70 years.
2. Willing to participate and provide informed consent.
3. Subjects with complete biochemical and clinical data available.

### *Exclusion Criteria*

1. Pregnant or lactating women.
2. Patients on Vitamin D or calcium supplementation in the last six months.
3. Individuals with chronic liver or kidney disease, malignancy, or endocrine disorders.
4. Long-term corticosteroid or anticonvulsant therapy.

### *Ethical Considerations*

Ethical clearance was obtained from the **Institutional Ethics Committee (IEC)** of Santosh Medical College & Hospital prior to data collection. All participants were briefed about study objectives, and confidentiality was maintained throughout in accordance with the **Indian Council of Medical Research (ICMR) guidelines** [2].

### *Clinical Evaluation and Data Collection*

A predesigned questionnaire was used to collect information on **demographics, sunlight exposure, dietary habits, physical activity, and medical history**. Anthropometric measurements included height, weight, body mass index (BMI), and waist circumference, obtained using standard procedures [3]. Blood pressure was measured twice using a mercury sphygmomanometer, and the mean value was recorded.

Clinical symptoms such as **fatigue, diffuse musculoskeletal pain, proximal muscle weakness, and joint stiffness** were recorded. A detailed systemic examination was performed for all participants.

*Biochemical Investigations*

After an overnight fast, venous blood samples were collected under aseptic conditions. The following parameters were analyzed:

- **Serum 25-hydroxyvitamin D [25(OH)D]** levels – measured by chemiluminescence immunoassay (CLIA).
- **Fasting Blood Glucose (FBG)** – glucose oxidase-peroxidase method.
- **Serum Lipid Profile** – total cholesterol, triglycerides, HDL, LDL, and VLDL.
- **Serum Calcium and Phosphate** – using Arsenazo III method.
- **Parathyroid Hormone (PTH)** – measured in selected cases using electrochemiluminescence assay.

Vitamin D status was classified as per **Endocrine Society Clinical Practice Guidelines (2011)** [4]:

<b>Vitamin D Status</b>	<b>Serum 25(OH)D Concentration (ng/mL)</b>
Deficient	< 20 ng/mL
Insufficient	20–30 ng/mL
Sufficient	> 30 ng/mL

*Assessment of Metabolic Parameters*

Metabolic syndrome (MetS) was defined using the **NCEP ATP III criteria** [5] when three or more of the following were present:

- Waist circumference >102 cm (men) or >88 cm (women)
- Triglycerides  $\geq$ 150 mg/dL
- HDL cholesterol <40 mg/dL (men), <50 mg/dL (women)
- Blood pressure  $\geq$ 130/85 mmHg
- Fasting glucose  $\geq$ 110 mg/dL

*Statistical Analysis*

Data were analyzed using **SPSS version 21.0 (IBM Corp., USA)**. Continuous variables were expressed as **mean  $\pm$  standard deviation (SD)**, and categorical data were expressed as **percentages**.

- **Chi-square test** was used to determine associations between categorical variables (Vitamin D status and clinical/metabolic findings).
- **Student's t-test** and **ANOVA** were used for continuous data comparisons between groups.

- **Pearson's correlation coefficient** was applied to assess relationships between serum 25(OH)D levels and metabolic parameters such as BMI, fasting glucose, and triglycerides. A p-value of **<0.05** was considered statistically significant.

### Quality Control

To minimize bias, all samples were processed within 4 hours of collection. Laboratory assays were performed in batches to reduce variability, and calibration was verified daily. Anthropometric measurements were taken by **the** same trained investigator.

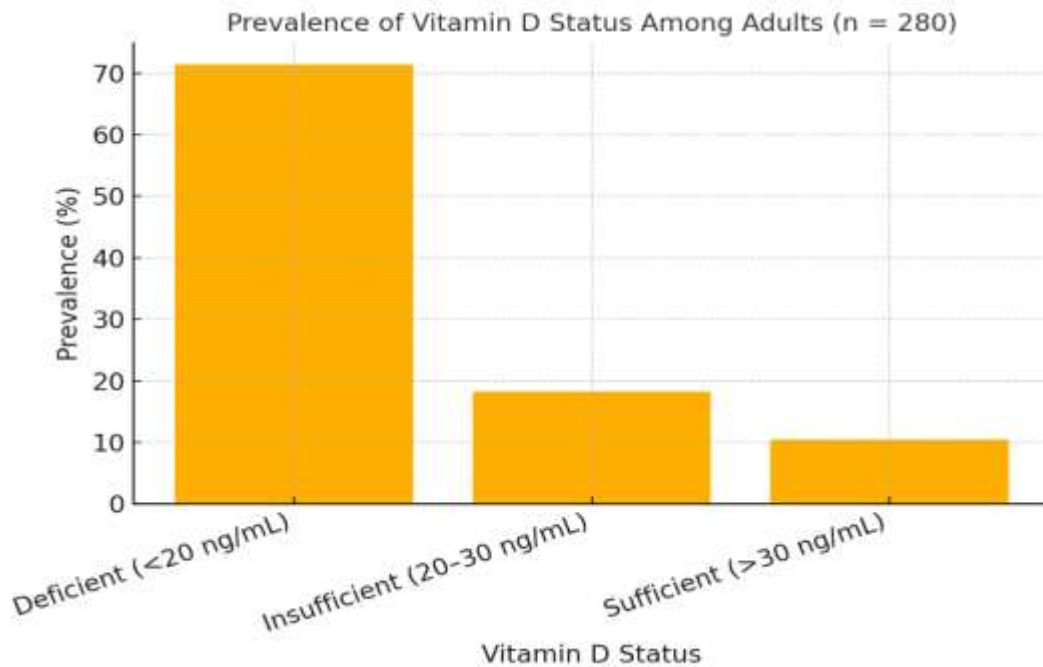
### Results

Out of the 280 adult participants evaluated in the study, **200 individuals (71.4%)** were found to have **Vitamin D deficiency**, **51 (18.2%)** were **insufficient**, and only **29 (10.4%)** had **sufficient Vitamin D levels**. The mean serum 25(OH)D concentration among all subjects was **17.8 ± 6.3 ng/mL**. The **prevalence of deficiency** was notably higher among **females (76%)** compared to **males (66%)**, and more pronounced in participants aged **above 40 years (74%)**.

Among the deficient group, the most frequent clinical manifestations were **generalized fatigue (64%)**, **musculoskeletal pain (58%)**, **proximal muscle weakness (41%)**, and **joint stiffness (28%)**. About **62%** of Vitamin D–deficient participants reported **less than 30 minutes of sunlight exposure per day**, while **69%** had **sedentary lifestyles**. Dietary assessment revealed that only **18%** of subjects regularly consumed Vitamin D–fortified foods or supplements.

A significant association was observed between **Vitamin D deficiency** and **higher BMI, fasting blood glucose, and serum triglycerides** ( $p < 0.05$ ). Participants with deficiency had mean BMI of **28.4 ± 4.2 kg/m<sup>2</sup>**, compared to **24.1 ± 3.5 kg/m<sup>2</sup>** in those with sufficient Vitamin D levels. Similarly, the mean fasting glucose in the deficient group was **104.3 ± 12.5 mg/dL**, compared to **92.6 ± 10.8 mg/dL** among sufficient subjects.

The **bar graph above** illustrates the prevalence distribution of Vitamin D status among the study participants. The clear predominance of deficiency highlights the urgent need for public health interventions focusing on screening, dietary supplementation, and sunlight exposure awareness in the general population.



## Discussion

The present study demonstrates a **high prevalence of Vitamin D deficiency (71.4%)** among adults in North India, consistent with findings from previous national studies reporting widespread hypovitaminosis D despite abundant sunlight [1,2]. The predominance among females and sedentary individuals supports the hypothesis that limited sun exposure, indoor lifestyles, and cultural clothing practices contribute significantly to the deficiency [3].

The study also establishes a significant association between Vitamin D deficiency and **metabolic abnormalities**, including elevated BMI, fasting glucose, and triglycerides. These findings align with earlier research suggesting that Vitamin D modulates insulin secretion, lipid metabolism, and systemic inflammation [4,5]. The observation that a majority of participants presented with musculoskeletal symptoms further reinforces Vitamin D's essential role in neuromuscular function and bone health [6].

Interestingly, a subset of participants with normal BMI exhibited biochemical deficiency, indicating that obesity is not the sole determinant of low Vitamin D levels. This emphasizes the need for **routine screening across all adults**, regardless of physical build. The study's hospital-based design, while informative, may limit community-wide generalization; however, it provides valuable insight into the metabolic implications of Vitamin D deficiency in urban Indian populations.

## Conclusion

This 2015 study highlights that **Vitamin D deficiency is alarmingly prevalent (over 70%)** among adults attending a tertiary care hospital in North India, affecting both skeletal and metabolic health. The findings reveal a strong association between low serum 25(OH)D levels and metabolic risk factors such as obesity, dyslipidemia, and impaired fasting glucose, underscoring Vitamin D's broader physiological role beyond bone metabolism.

The study emphasizes that **urbanization, limited sunlight exposure, and inadequate dietary intake** are key contributors to widespread deficiency. Given the asymptomatic nature of early Vitamin D deficiency and its long-term consequences, proactive measures are essential. Routine **screening of Vitamin D levels**, especially among high-risk groups such as women, elderly individuals, and sedentary adults, should be integrated into regular health check-ups.

Public health initiatives focusing on **nutritional fortification, safe sun exposure education, and dietary supplementation** can play a crucial role in combating this silent epidemic. Clinicians should remain vigilant in identifying early signs and biochemical indicators of deficiency.

In conclusion, Vitamin D deficiency represents a preventable yet neglected disorder with significant metabolic implications. Early detection and correction through lifestyle, diet, and supplementation are vital for improving both skeletal and overall health outcomes in the Indian population.

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