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Original Research Article

Prevalence of Vitamin D Deficiency and Its Association with Growth Parameters in Children Aged 1–10 Years: A Cross-Sectional Study

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Abstract:

Background: Vitamin D plays a crucial role in skeletal growth and overall child development. Despite adequate sunlight, vitamin D deficiency is highly prevalent among Indian children and may adversely affect growth parameters.

Aim: To estimate the prevalence of vitamin D deficiency and examine its association with growth parameters among children aged 1–10 years.

Methodology: A hospital-based cross-sectional study was conducted among 600 children aged 1–10 years attending a Upgraded Department of Pediatrics, Patna Medical College and Hospital, Patna, Bihar, India. Serum 25-hydroxyvitamin D levels were measured and classified as deficient, insufficient, or sufficient. Anthropometric measurements were recorded, and growth indices (HAZ, WAZ, BAZ) were calculated using WHO standards. Statistical analyses assessed associations between vitamin D status, growth parameters, and potential determinants.

Results: Vitamin D deficiency was observed in 55% of children, while 28.3% had insufficiency. Deficient children had significantly lower height, weight, BMI, and mean HAZ, WAZ, and BAZ scores compared to sufficient children ($p<0.001$). Stunting, underweight, and thinness were significantly more prevalent among vitamin D–deficient children. Limited sun exposure, lack of supplementation, rural residence, and younger age were key determinants of deficiency.

Conclusion: Vitamin D deficiency is highly prevalent and significantly associated with impaired growth among children. Early screening and targeted interventions are essential to improve child growth and nutritional outcomes.

Keywords: Vitamin D Deficiency, Children, Growth Parameters, Stunting, Anthropometry, Cross-Sectional Study.

Introduction

Vitamin D is a vital micronutrient that is critical in the calcium and phosphate homeostasis, mineralization of the bones, and general growth in childhood. Sufficient levels of vitamin D are essential in the development of bones, linear growth and the prevention of rickets and other skeletal defects. In addition to its classical effects on bone health, the future is likely to show that vitamin D can have effects on muscle functions, immune homeostasis, and metabolism, therefore, improving the overall health and growth of a child. Although tropical countries like India have a lot of sunlight, Vitamin D deficiency has become a major challenge to the health of the country's population despite the fact that they look healthy and well fed.

Indian studies have repeatedly shown that the number of pediatric hypovitaminosis D is significantly high thus showing that Vitamin D deficiency is not limited to children with advanced malnutrition or chronic ailments. Causes of this ironic deficiency include insufficient sunlight exposure owing to indoor lifestyles, air pollution, clothing habits, dietary deficiency of vitamin D and lack of regular supplementing. Angurana et al. in a study carried out in North India found out that a large proportion of apparently healthy children were suffering vitamin D deficiency, which is an invisible deficiency of a micronutrient, and is likely to remain undiagnosed in the normal clinical setting [1]. The latter results reveal the necessity of increased awareness and methodical assessment of the vitamin D level of children, without any apparent clinical signs.

A biomarker that is most commonly considered to be the most reliable technique to decide on the status of vitamin D is serum 25-hydroxyvitamin D

(25[OH]D) because it is a stable biomarker indicating the overall amount of vitamin D that is obtained through endogenous synthesis and by dietary intake. Nonetheless, there is still much controversy on the best cutoff values to determine vitamin D deficiency, insufficiency, and sufficiency especially in children. Traditional thresholds have been defined by bone health outcomes, although recent studies have proposed that other non-skeletal consequences may be of importance in defining deficiency. Sharifi et al. suggested a vitamin D deficiency cutoff based on correlations with insulin resistance markers in children and showed that vitamin D status may have metabolic consequences beyond skeletal growth and that selection of cutoff values can have a significant effect on prevalence estimates [2]. This inconsistency in definitions as well as the differences in geographic location, exposure to sunlight, dietary patterns as well as supplementation practices add to the broad heterogeneity of quoted prevalence rates and make cross-studies and cross-region comparisons difficult.

Although it is important to estimate prevalence of vitamin D deficiency, it is equally important to determine its impact on child growth, which has a great role to play in terms of public health. Childhood development is a sensitive measure of health and nutritional condition and any deficiency in childhood development may have long term effects that may be seen in adulthood. There is increasing interest in investigating the relationship between vitamin D deficiency and poor growth outcomes including underweight, stunted growth and low height for age or weight for age indices. Studies performed outside India indicate the possibility of the relationship between low vitamin D levels and poor growth. Mokhtar et al. have shown a correlation between underweight and stunting and vitamin D status among young children in the Ecuadorian Andes to give both biological and epidemiological reasons to examine growth correlates of vitamin D in young children [3]. Nevertheless, the magnitude, direction and consistency of these associations might differ between settings because of variation in baseline nutritional status, infections burden, socioeconomic status as well as environment.

In the Indian context, multicentric studies have supported the fact that the deficiency of vitamin D is very significant and occurs as a result of complex interaction of demographic, environmental, and lifestyle factors. In their study, a large multicentre investigation of Indian children and adolescents, Khadilkar et al. reported the distribution of vitamin D status in various regions and determined the determinants of vitamin D status as age, sex, geographic location, and environmental exposures [4]. These results underline the fact that the lack of vitamin D can be explained by a complex of factors and cannot be attributed to one condition. Critically, this evidence demonstrates that region-specific data is necessary since risk profiles can vary significantly across urban, rural, coastal, and semi-rural locations. Regions near the coast, though abundant in sunshine, can still have high deficiency levels due to high humidity, cloud cover, cultural practices of dressing and lack of outdoor activities.

The same multicenter evidence base also stresses the necessity of concomitantly evaluating the possible determinants including sunlight exposure, dietary intake, supplementation practices, as well as socioeconomic position with respect to investigating the relationship between vitamin D status and growth parameters. These factors might not be taken into consideration and therefore can confound the associations [5] as well as reduce the interpretation of the study results. Thus, the research on growth correlates vitamin d deficiency ought to incorporate a holistic evaluation of the relevant exposures and contextual variables because they can help to clarify existing underlying relationships.

In this regard, the current cross-sectional study aimed at determining the prevalence of vitamin D deficiency in children aged 1-10 years old who were enrolled in Department of Pediatrics, Patna Medical College and Hospital (PMCH), Patna, Bihar, India. Moreover, the purpose of the study is to test the correlation between the vitamin D status and the anthropometric growth indicators, taking into consideration the major determinants of demographic and exposure parameters. Creation of geographically relevant evidence regarding deficiency in vitamin D and its possible growth effects can be used to inform localized screening, preventive measures, and local health intervention efforts among the local population of pediatrics.

Methodology

Study Design and Study Area: A hospital-based cross-sectional study was conducted in the Upgraded Department of Pediatrics, Patna Medical College and Hospital (PMCH), Patna, Bihar, India.

Study Duration: The study was carried out over a period of one year, from July December 2024 to June 2025.

Study Population: The study population comprised children aged 1–10 years attending the pediatric outpatient department (OPD) and/or admitted to the pediatric wards of PMCH for non-critical illnesses during the study period.

Sample Size: A total of 600 children were included in the study. The sample size was based on feasibility and patient load during the study period.

Sampling Method: Consecutive sampling was employed, wherein all eligible children presenting during the study period were enrolled until the required sample size was achieved.

Inclusion Criteria

- Children aged 1–10 years
- Children attending pediatric OPD or admitted for non-critical conditions
- Parents or legal guardians who provided written informed consent

Exclusion Criteria

Children were excluded if they had:

- Chronic renal disease or chronic liver disease
- Malabsorption syndromes
- Endocrine disorders affecting growth or vitamin D metabolism
- Genetic or syndromic conditions influencing growth
- History of therapeutic (high-dose) vitamin D supplementation within the last three months
- Critical illness requiring emergency care or resuscitation

Data Collection: Data were collected using a pre-designed and structured case record form. Information recorded included demographic details such as age, sex, place of residence (urban/rural), and socioeconomic status. Exposure-related variables included season of sampling, average daily sun exposure (hours per day), level of outdoor physical activity, dietary intake frequency (milk, egg, and fish consumption expressed as days per week), and history of vitamin D supplementation in the preceding three months.

Anthropometric Measurements and Growth Assessment: Anthropometric measurements were performed for all enrolled children to assess growth parameters. Weight was measured using a calibrated digital weighing scale with children wearing light clothing and no footwear. Standing height was measured using a stadiometer for children above 2 years of age, while recumbent length was measured using a length board for younger children. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). Age- and sex-specific Z-scores were derived using WHO reference standards, including height-for-age Z-score (HAZ), weight-for-age Z-score (WAZ), and BMI-for-age Z-score (BAZ). Nutritional status was categorized based on these indices: stunting (HAZ < -2), underweight (WAZ < -2), thinness (BAZ < -2), overweight (BAZ $> +1$), and obesity (BAZ $> +2$). These measurements provided standardized assessments of growth and nutritional status for comparison across different vitamin D categories.

Laboratory Assessment and Definition of Vitamin D Status: Venous blood samples (2–3 mL) were collected from all participants under aseptic precautions by trained personnel. Serum 25-hydroxyvitamin D [25(OH)D] levels were measured in the institutional laboratory using a standardized immunoassay, with routine internal quality control procedures to ensure accuracy. Where available, serum calcium and alkaline phosphatase levels were also recorded. Vitamin D status was classified according to widely accepted criteria: deficiency (<20 ng/mL), insufficiency (20–29 ng/mL), and sufficiency (≥30 ng/mL). These measurements were used to determine the prevalence of vitamin D deficiency and to explore its association with growth and nutritional parameters.

Outcome Measures: The primary outcome of the study was the prevalence of vitamin D deficiency among children aged 1–10 years. Secondary outcomes included the association between vitamin D status and growth parameters such as height, weight, BMI, and the corresponding Z-scores (HAZ, WAZ, BAZ). Additionally, the relationship between vitamin D status and categorical nutritional outcomes—stunting, underweight, thinness, overweight, and obesity—was assessed. The study also aimed to identify potential determinants of vitamin D deficiency, including demographic, lifestyle, and dietary factors.

Statistical Analysis: All collected data were entered into a secure database and analyzed using appropriate statistical software. Continuous variables were summarized as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Prevalence estimates for vitamin D deficiency were reported with 95% confidence intervals. Comparisons across vitamin D categories were conducted using one-way ANOVA for continuous variables and chi-square tests for categorical variables. Multivariable linear regression analysis was performed to assess associations between serum vitamin D levels and growth Z-scores (HAZ, WAZ, BAZ), whereas multivariable logistic regression was used to evaluate determinants of vitamin D deficiency and its association with binary nutritional outcomes. All models were adjusted for potential confounders, including age, sex, residence, socioeconomic status, season, sun exposure, outdoor activity, dietary intake, and recent vitamin D supplementation. A p-value <0.05 was considered statistically significant."

Result

Table 1 outlines the baseline characteristics of the 600 study participants. Children aged 4–6 years and 7–10 years each constituted the largest age groups (210, 35% each), while those aged 1–3 years accounted for 180 participants (30%). Males slightly outnumbered females (330, 55% vs 270, 45%). A marginally higher proportion of participants resided in rural areas (310, 51.7%) compared with urban areas (290, 48.3%). Most children belonged to lower (260, 43.3%) or middle (240, 40%) socioeconomic strata, with only 100 (16.7%) from upper socioeconomic status. Notably, vitamin D supplementation in the preceding three months was reported by only 140 participants (23.3%), whereas the majority (460, 76.7%) had not received supplementation, highlighting a potential risk factor for vitamin D deficiency in this population.

Table 1: Baseline Characteristics of the Study Population (N = 600)

Variable	Frequency (n)	Percentage (%)
Age group (years)		
1–3	180	30
4–6	210	35
7–10	210	35
Sex		
Male	330	55
Female	270	45
Residence		
Urban	290	48.3
Rural	310	51.7
Socioeconomic status		
Lower	260	43.3
Middle	240	40
Upper	100	16.7
Vitamin D supplementation in last 3 months		
Yes	140	23.3
No	460	76.7

Table 2 shows the distribution of serum vitamin D status among 600 study participants. More than half of the participants were vitamin D deficient, with 330 individuals (55%) having serum 25(OH)D levels below 20 ng/mL. Vitamin D insufficiency (20–29 ng/mL) was observed in 170 participants (28.3%), while only 100 participants (16.7%) had sufficient vitamin D levels (≥30 ng/mL). Overall, the findings indicate a high prevalence of suboptimal vitamin D status in the study population.

Table 2: Distribution of Serum Vitamin D Status Among Study Participants (N = 600)

Vitamin D status	Serum 25(OH)D level (ng/mL)	n	%
Deficiency	<20	330	55
Insufficiency	20–29	170	28.3
Sufficiency	≥30	100	16.7

Table 3 compares anthropometric and growth parameters across vitamin D status groups and demonstrates a consistent positive association between vitamin D sufficiency and better growth indicators. Mean height increased from 99.8 ± 12.4 cm in deficient children to 103.6 ± 11.8 cm in insufficient and 107.9 ± 10.9 cm in sufficient children (p<0.001), with a similar trend observed for weight (14.1 ± 3.5 kg, 15.6 ± 3.4 kg, and 17.2 ± 3.6 kg, respectively; p<0.001). BMI also rose progressively with improving vitamin D status (14.1 ± 1.6, 14.7 ± 1.5, and 15.3 ± 1.4 kg/m²; p=0.002). Correspondingly, mean z-scores for height-for-age (HAZ), weight-for-age (WAZ), and BMI-for-age (BAZ) were lowest in the deficient group and improved stepwise in the insufficient and sufficient groups (all p<0.001). Overall, children with sufficient vitamin D levels exhibited significantly better anthropometric and growth outcomes than those who were deficient or insufficient.

Table 3: Anthropometric and Growth Parameters According to Vitamin D Status

Parameter	Deficient (n = 330)	Insufficient (n = 170)	Sufficient (n = 100)	p-value
Height (cm)	99.8 ± 12.4	103.6 ± 11.8	107.9 ± 10.9	<0.001
Weight (kg)	14.1 ± 3.5	15.6 ± 3.4	17.2 ± 3.6	<0.001
BMI (kg/m²)	14.1 ± 1.6	14.7 ± 1.5	15.3 ± 1.4	0.002
HAZ	−1.52 ± 0.96	−1.10 ± 0.88	−0.62 ± 0.81	<0.001
WAZ	−1.41 ± 0.91	−1.02 ± 0.86	−0.58 ± 0.79	<0.001
BAZ	−1.28 ± 0.84	−0.94 ± 0.79	−0.51 ± 0.72	<0.001

Table 4 shows a clear association between vitamin D status and nutritional status among 600 children. Stunting was most prevalent in vitamin D–deficient children (118, 35.8%), decreasing progressively in the insufficient (42, 24.7%) and sufficient groups (12, 12.0%; p<0.001). A similar gradient was observed for underweight status, affecting 30.9% of deficient children compared with 21.2% of insufficient and 10.0% of sufficient children (p<0.001), as well as for thinness (25.5%, 16.5%, and 6.0%, respectively; p=0.001). In contrast, overweight and obesity were least common among vitamin D–deficient children (5.5%) and increased with improving vitamin D status, reaching 14.0% in the sufficient group (p=0.01). Overall, poorer vitamin D status was significantly associated with undernutrition, while better vitamin D status was more frequently observed among overweight or obese children.

Table 4: Nutritional Status of Children According to Vitamin D Status (N = 600)

Nutritional status	Deficient (n = 330)	Insufficient (n = 170)	Sufficient (n = 100)	p-value
Stunting (HAZ < −2)	118 (35.8)	42 (24.7)	12 (12.0)	<0.001
Underweight (WAZ < −2)	102 (30.9)	36 (21.2)	10 (10.0)	<0.001
Thinness (BAZ < −2)	84 (25.5)	28 (16.5)	6 (6.0)	0.001
Overweight/Obesity	18 (5.5)	16 (9.4)	14 (14.0)	0.01

Table 5 presents the multivariable logistic regression analysis identifying determinants of vitamin D deficiency among 600 participants. Children younger than 5 years had significantly higher odds of vitamin D deficiency (aOR = 1.62; 95% CI: 1.12–2.36; p = 0.01). Rural residence was also a significant risk factor (aOR = 1.74; 95% CI: 1.22–2.48; p = 0.002). Limited sun exposure of less than 1 hour per day showed the strongest association with deficiency (aOR = 2.36; 95% CI: 1.65–3.38; p < 0.001), followed by absence of vitamin D supplementation (aOR = 2.01; 95% CI: 1.36–2.98; p < 0.001) and low dietary intake (aOR = 1.58; 95% CI: 1.09–2.29; p = 0.015). Female sex was associated with higher odds but did not reach statistical significance (aOR = 1.28; 95% CI: 0.92–1.79; p = 0.14). Overall, modifiable factors related to sun exposure, supplementation, and diet were the key determinants of vitamin D deficiency.

Table 5: Multivariable Logistic Regression Analysis for Determinants of Vitamin D Deficiency (N = 600)

Variable	Adjusted Odds Ratio (aOR)	95% Confidence Interval	p-value
Age <5 years	1.62	1.12–2.36	0.01
Female sex	1.28	0.92–1.79	0.14
Rural residence	1.74	1.22–2.48	0.002
Sun exposure <1 hour/day	2.36	1.65–3.38	<0.001
No vitamin D supplementation	2.01	1.36–2.98	<0.001
Low dietary intake	1.58	1.09–2.29	0.015

Discussion

This current research shows that the burden of hypovitaminosis D among the children aged 1-10 years is high with 55 percent of the children being vitamin D deficient and 28.3 percent are insufficient with respect to vitamin D levels, thus depicting that almost 83 percent of children have poor vitamin D levels. It is also significantly greater than that of the coastal Sindhudurg study (2010) where vitamin D deficiency was found to be present in 40.2 percent of children and general insufficiency / deficiency (<30 ng/mL) in 65.4 percent of the subjects. Although geographically different, both articles support the finding that the prevalence of vitamin D deficiency even in sun-rich and coast-geographical areas is high, indicating that even the access to sunlight in the environment may be insufficient to guarantee a proper level of vitamin D among children (Joshi & Bhatia, 2014) [6]. This increased prevalence in our study could be explained by the larger sample size, the inclusion of younger children in the studies, the low levels of supplementation, and potentially different socioeconomic and lifestyle factors.”

The trends of vitamin D deficiency in elderly people that we noticed during our research also coincide with the existing literature, but there is a slight divergence in the direction of association. Although children younger than five years were found to have greater odds of vitamin D deficiency in our multivariate regression (aOR 1.62), Sindhudurg study found that the prevalence was higher among older children aged 610 years (45.4 36.7). Correspondingly, Vasudevan et al. (2014) [7] found out that the odds of deficiency increased with age (OR 1.3), implying that cumulative lifestyle approaches, less involvement in outdoor activities, and schooling patterns could predispose older children to deficiency. Conversely, our results can be attributed to poor infant and early-childhood supplementation and nutrition, which is in line with the findings of Jain et al. (2011) [8] who reported that children and their mothers had high levels of vitamin D deficiency, and thus, early life sources of vitamin D deficiency.

The correlation of vitamin D status and parameters of growth in our study was very strong. Mean height, weight, BMI and Z-scores of height-for-ages, weight-for-age and BMI-for-age of children with vitamin D deficiency were significantly lower than the same of children who were sufficient with vitamin D. Our cohort reported a mean HAZ of -1.52 in our deficient children, which is considerably less than -1.06 in the Sindhudurg study indicating that there is a more severe growth deficit among our deficient population. This difference can be attributed to the fact that undernutrition was more prevalent, and the socioeconomic status of our sample was lower since 83.3% of children were lower or middle socioeconomic status. Nevertheless, these two studies both show that a deficiency of vitamin D is correlated with a worse linear growth on continuous scales even when more objective outcomes like stunting are not significant in certain contexts (Joshi & Bhatia, 2014) [6].

However, our results of very high stunting (35.8%), underweight (30.9%), and thinness (25.5%) in children with vitamin D deficiency are in contrast with those of Sindhudurg which statistically did not find the categories outcomes, even though the point estimates were higher. This disparity can be due to a better statistical power in our bigger sample size (n=600 vs n=400) and increased weight of nutritional deprivation. Categorical growth results have been reported as being similar in Sharif et al. (2020) [9] in which levels of vitamin D were low in both stunted and non-stunted Indonesian children, which limits the discriminatory ability between the two groups. These findings hint that the contribution of vitamin D deficiency to the continuous growth indices can be more discernible before it starts being reflected on anthropometric shortages in a cross-sectional study.

The sunlight exposure role that we have seen in the study is highly supportive of literature. Children who received less than one hour of sun time per day were more than twice as likely to be vitamin D deficient (aOR 2.36), and insufficient effective exposure to UVB emerged as an essential factor. Similarly, Mandlik et al. [10] reported that even though more than two-thirds of children who spent over eight hours exposed to the sun each day, 71% of children were still vitamin D-deficient, and only the length of time in the sun might not be relevant to assessing effective cutaneous synthesis because of clothing, timing of exposure to the sun, and skin pigmentation, as well as air pollution. Our results build upon these pieces of evidence and measure the independent impact of restricted exposure in younger age group.

Food and supplementation were also found to be influential modifiable variables in our analysis. The odds of deficiency were twice among children who were not given vitamin D supplements, which were in agreement with the results of Jain et al. (2011) [8], who found that supplementation was a significant protective factor in infants. Although randomized trials have proven the feasibility and efficacy of the intervention of daily vitamin D supplementation in Indian schoolchildren (Marwaha et al., 2019) [11] provide evidence, although the coverage of the intervention in our cohort was low (23.3%), indicating an essential lack of alignment between evidence and practice.

Even though the children with sufficient levels of vitamin D were even more likely to be overweight and obese in our study, the prevalence was still low. This trend is opposite to the findings of other studies in high-adiposity groups where vitamin D bioavailability and response to supplementation can be dampened (Hauger et al., 2020) [12]. Such interaction would be important to be assessed longitudinally in future due to the increasing trends in childhood obesity in urban India.

In general, our results are in line with Indian studies of large-scale laboratory surveillance that show that vitamin D deficiency is prevalent, albeit with regional, seasonal, and sampling frame variation in prevalence (Raizada et al., 2020) [13]. Our deficiency prevalence was a little less than these reports, which may have been due to coastal living, but the close links to growth and risk factors that could be altered support the clinical and population health importance of vitamin D testing in childhood. Altogether, the evidence indicates that vitamin D deficiency is extremely common among Indian children, and that it is linked to compromised growth parameters, and that it needs collaborative measures that encompass the use of supplements, improvement of the diet, and effective exposure to sunlight in terms of region-specific and age-specific considerations.

Conclusion

This cross-sectional examination shows that the state of vitamin D deficiency is very high among children between the ages of one and ten years and is closely related to worse development and nutrition outcomes. Children with a deficient vitamin D condition always recorded lower anthropometry and unfavorable growth indices when compared with those inadequately endowed with vitamin D and averagely maintained implying that there is indeed a positive correlation between vitamin D status and linear growth, body weight, and general nutritional status. Higher rates of stunting, underweight, and thinness were observed among vitamin D–deficient children, while adequate vitamin D status was linked with better growth profiles. Factors such as younger age, rural residence, limited sun exposure, lack of vitamin D supplementation, and inadequate dietary intake emerged as important determinants of deficiency. These findings highlight the need for early identification of vitamin D deficiency and the implementation of targeted public health strategies, including nutritional interventions, supplementation, and promotion of safe sun exposure, to improve growth outcomes and overall child health.

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