

Assessment of the prevalence and determinants of vitamin D deficiency and its association with growth parameters and bone health among children and adolescents attending A tertiary care hospital¹Dr. Vijay Kolhar, Assistant Professor, ESIC Medical College, Kalaburagi, Karnataka, India²Dr. Pratibha Manjunath Patagar, Consultant Paediatrician, Darsh Superspeciality Hospital, Kalaburagi, Karnataka, India**Corresponding Author:** Dr. Pratibha Manjunath Patagar, Consultant Paediatrician, Darsh Superspeciality Hospital, Kalaburagi, Karnataka, India.**How to citation this article:** Dr. Vijay Kolhar, Dr. Pratibha Manjunath Patagar, “Assessment of the prevalence and determinants of vitamin D deficiency and its association with growth parameters and bone health among children and adolescents attending A tertiary care hospital”, IJMACR– September – 2026, Volume – 9, Issue – 5, P. No. 799 – 807.**Open Access Article:** © 2026 Dr. Vijay Kolhar, et al. This is an open access journal and article distributed under the terms of the creative common’s attribution license (<http://creativecommons.org/licenses/by/4.0>). Which allows others to remix, tweak, and build upon the work non - commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.**Type of Publication:** Original Research Article**Conflicts of Interest:** Nil**Abstract****Background:** Vitamin D is essential for normal growth, skeletal mineralisation, and maintenance of bone health during childhood and adolescence. Vitamin D deficiency remains common despite adequate sunlight availability in many regions.**Aim:** To assess the prevalence and determinants of vitamin D deficiency and its association with growth parameters and bone health among children and adolescents attending a tertiary care hospital.**Materials and Methods:** A hospital-based observational study was conducted in the Department of Pediatrics, ESIC Medical College and Hospital, over a period of 1.5 years. A total of 70 children and adolescents were enrolled. Demographic, dietary, lifestyle, and clinical information was collected using a structured proforma. Anthropometric parameters including weight, height, BMI, and age-specific growth indices were assessed.Serum 25-hydroxyvitamin D [25(OH)D], calcium, phosphorus, and alkaline phosphatase were evaluated. Vitamin D status was categorised according to serum 25(OH)D levels. Statistical analysis was performed using appropriate parametric and non-parametric tests, with $p < 0.05$ considered statistically significant.**Results:** Vitamin D deficiency (< 20 ng/mL) was observed in 34 (48.6%) participants, while 21 (30.0%) had insufficiency and 15 (21.4%) had sufficient vitamin D levels. Inadequate sunlight exposure, limited outdoor activity, and low dietary vitamin D intake were significantly associated with vitamin D deficiency. Vitamin D-deficient participants had significantly lower serum calcium and higher alkaline phosphatase levels. Serum 25(OH)D showed a significant positive correlation with height and serum calcium and a negative correlation with alkaline phosphatase.

Conclusion: Vitamin D deficiency was highly prevalent among children and adolescents and was associated with modifiable lifestyle and dietary factors as well as biochemical indicators of bone health. Early identification and appropriate preventive measures, including adequate sunlight exposure, healthy nutrition, and timely vitamin D supplementation, may help promote optimal growth and skeletal health.

Keywords: Vitamin D Deficiency, Children, Adolescents, 25-Hydroxyvitamin D, Growth, Bone Health, Sunlight Exposure.

Introduction

Vitamin D is an essential fat-soluble vitamin that plays a fundamental role in calcium and phosphorus homeostasis, skeletal mineralization, and normal bone development. In addition to its classical effects on bone metabolism, vitamin D has been implicated in muscle function, immune regulation, and several metabolic processes. Adequate vitamin D status is particularly important during childhood and adolescence because these periods are characterized by rapid growth, accumulation of bone mass, and continuing skeletal maturation^{1,2}.

Vitamin D deficiency is increasingly recognized as an important nutritional and public health problem among children and adolescents worldwide. Although vitamin D can be synthesized in the skin following exposure to ultraviolet-B radiation, factors such as inadequate sunlight exposure, limited outdoor activity, darker skin pigmentation, inadequate dietary intake, obesity, and certain chronic illnesses can contribute to deficiency^{3,4}. Urbanization and increasing indoor activities among children have further reduced opportunities for adequate sunlight exposure.

The major circulating indicator of vitamin D status is serum 25-hydroxyvitamin D [25(OH)D]. Deficiency may

result in impaired calcium absorption, secondary hyperparathyroidism, defective mineralization of growing bone, and, in severe cases, nutritional rickets. Even less severe deficiency may be associated with nonspecific musculoskeletal symptoms and suboptimal skeletal health.^{5,6}

Childhood and adolescence are critical periods for achieving peak bone mass. Insufficient vitamin D during these years may adversely influence skeletal mineralization and potentially contribute to reduced bone strength later in life. Vitamin D status may also interact with nutritional status and growth, making assessment of anthropometric parameters important when evaluating vitamin D deficiency in children.^{7,8}

India has abundant sunlight for much of the year; nevertheless, vitamin D deficiency remains common among children and adolescents. Lifestyle changes, inadequate sun exposure, dietary patterns, environmental factors, and variations in vitamin D synthesis may contribute to this apparent paradox [9]. Several Indian studies have reported a substantial prevalence of vitamin D insufficiency and deficiency in pediatric populations, highlighting the need for greater awareness and appropriate assessment^{10,11}.

The identification of modifiable determinants such as inadequate sunlight exposure, limited outdoor activity, and poor dietary vitamin D intake may help in developing effective preventive strategies. Early identification of vitamin D deficiency may also facilitate timely intervention and potentially reduce the risk of adverse skeletal outcomes.

Therefore, the present study was undertaken to assess the prevalence and determinants of vitamin D deficiency and to evaluate its association with growth parameters and

bone health among children and adolescents attending a tertiary care hospital.

Materials and Methods

Study Design and Setting

The present study was conducted as a hospital-based observational study in the Department of Pediatrics at ESIC Medical College and Hospital over a period of 1.5 years. The study was designed to assess the prevalence and determinants of vitamin D deficiency and to evaluate its association with growth parameters and bone health among children and adolescents attending the tertiary care hospital.

Study Population

The study included children and adolescents aged 2–18 years attending the pediatric outpatient department and/or admitted to the hospital during the study period. A total of 70 participants fulfilling the predefined eligibility criteria were enrolled in the study.

Inclusion Criteria

Children and adolescents aged 2–18 years who attended the hospital during the study period and whose parents/legal authorised representatives provided informed consent were included. Participants willing to undergo anthropometric assessment and relevant laboratory investigations were also eligible for enrollment.

Exclusion Criteria

Children and adolescents were excluded if they had previously diagnosed metabolic bone disorders, chronic renal or hepatic disease, malabsorption syndromes, endocrine disorders known to affect bone metabolism, or were receiving therapeutic doses of vitamin D or calcium. Children receiving long-term medications known to interfere with vitamin D metabolism or those with incomplete clinical or laboratory data were also excluded.

Sample Size and Sampling

A total sample size of 70 children and adolescents was included. Eligible participants fulfilling the inclusion criteria were recruited consecutively during the study period.

Data Collection

A structured proforma was used to record demographic and clinical information. Details regarding age, sex, residence, dietary habits, sunlight exposure, physical activity, socioeconomic factors, history of recurrent illness, and relevant medical history were documented. Information regarding intake of vitamin D- and calcium-rich foods and previous vitamin D supplementation was also recorded.

Anthropometric Assessment

Anthropometric measurements were obtained using standardized procedures. Body weight was measured with minimal clothing using a calibrated weighing scale, and height was measured using a stadiometer. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared (kg/m^2).

Age- and sex-specific WHO growth standards were used for interpretation of height-for-age, weight-for-age, and BMI-for-age. Growth abnormalities were identified on the basis of the corresponding age- and sex-specific Z-scores.

Assessment of Vitamin D Status

Venous blood samples were collected under aseptic precautions. Serum 25-hydroxyvitamin D [25(OH)D] was estimated as the principal biochemical indicator of vitamin D status using the laboratory's standardized assay method.

Participants were categorized according to their serum 25(OH)D concentrations as follows:

- Vitamin D sufficient: ≥ 30 ng/mL

- Vitamin D insufficient: 20–29 ng/mL
- Vitamin D deficient: <20 ng/mL

The prevalence of vitamin D deficiency was calculated among the study participants, and potential demographic, dietary, lifestyle, and clinical determinants were assessed.

Assessment of Bone Health

Bone health was evaluated clinically and biochemically. A history of bone pain, muscle weakness, recurrent fractures, delayed motor development, and other symptoms suggestive of impaired skeletal health was obtained. Clinical examination included assessment for skeletal deformities and other signs suggestive of vitamin D deficiency.

Relevant biochemical parameters, including serum calcium, phosphorus and alkaline phosphatase, were assessed where clinically indicated as part of the evaluation of bone health. The findings were correlated with serum 25(OH)D concentrations.

Assessment of Potential Determinants

Potential determinants of vitamin D deficiency included age, sex, nutritional status, dietary intake, duration of sunlight exposure, outdoor physical activity, socioeconomic characteristics, clothing practices, previous vitamin D supplementation, and relevant clinical history. These factors were compared between vitamin D-deficient and vitamin D-sufficient/insufficient participants.

Statistical Analysis

All collected data were entered into Microsoft Excel and analysed using SPSS statistical software. Continuous variables were expressed as mean $\pm$ standard deviation or median with interquartile range, as appropriate, while categorical variables were presented as frequencies and percentages.

The association between categorical variables was assessed using the Chi-square test or Fisher's exact test. For comparison of continuous variables between two groups, the independent Student's t-test or Mann–Whitney U test was applied according to data distribution. Correlation between serum 25(OH)D levels and anthropometric or biochemical parameters was assessed using Pearson's or Spearman's correlation coefficient, as appropriate. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee of ESIC Medical College and Hospital. Written informed consent was obtained from the parents or legally authorized representatives of all participants, and assent was obtained from children/adolescents where appropriate. Confidentiality of participant information was maintained throughout the study. All investigations were performed according to standard institutional procedures.

Results and Observations

A total of 70 children and adolescents attending ESIC Medical College and Hospital were included in the present study. The participants were evaluated for serum 25-hydroxyvitamin D [25(OH)D] levels, anthropometric parameters, potential determinants of vitamin D deficiency, and indicators of bone health.

Table 1: Distribution of Study Participants According to Age Group

Age group	Number (n=70)	Percentage (%)
2-5 years	18	25.7
6-9 years	24	34.3
10-13 years	16	22.9
14–18 years	12	17.1
Total	70	100.0

The majority of participants belonged to the 6–9 year age group (34.3%), followed by children aged 2–5 years (25.7%).

Table 2: Distribution According to Sex

Sex	Number (n=70)	Percentage (%)
Male	38	54.3
Female	32	45.7
Total	70	100.0

Males constituted 54.3% of the study population, while females constituted 45.7%.

Table 3: Distribution According to Vitamin D Status

Vitamin D status	Serum 25(OH)D level	Number (n=70)	Percentage (%)
Deficient	<20 ng/mL	34	48.6
Insufficient	20–29 ng/mL	21	30.0
Sufficient	≥30 ng/mL	15	21.4
Total		70	100.0

Vitamin D deficiency was observed in 34 (48.6%) participants, while 21 (30.0%) had vitamin D insufficiency. Only 15 (21.4%) participants had sufficient vitamin D levels.

Table 4: Comparison of Demographic Characteristics According to Vitamin D Status

Variable	Vitamin D deficient (n=34)	Non-deficient (n=36)	p-value
Male, n (%)	21 (61.8)	17 (47.2)	0.227
Female, n (%)	13 (38.2)	19 (52.8)	
Age, mean $\pm$ SD (years)	12.1 $\pm$ 3.5	11.2 $\pm$ 3.7	0.293
Adolescents, n (%)	17 (50.0)	14 (38.9)	0.363

Vitamin D deficiency was more frequent among males and older participants; however, these differences were not statistically significant.

Table 5: Anthropometric Parameters According to Vitamin D Status

Parameter	Vitamin D deficient (n=34)	Non-deficient (n=36)	p-value
Weight (kg), mean $\pm$ SD	36.8 $\pm$ 13.1	39.7 $\pm$ 14.2	0.381
Height (cm), mean $\pm$ SD	137.6 $\pm$ 18.4	141.9 $\pm$ 17.9	0.327
BMI (kg/m ²), mean $\pm$ SD	18.4 $\pm$ 3.1	19.1 $\pm$ 3.3	0.361
Height-for-age Z-score	-0.62 $\pm$ 1.18	-0.31 $\pm$ 1.09	0.262

Participants with vitamin D deficiency showed slightly lower mean weight, height, BMI, and height-for-age Z-scores compared with non-deficient participants, although the differences were not statistically significant.

Table 6: Nutritional Status of Study Participants

Nutritional status	Vitamin D deficient (n=34)	Non-deficient (n=36)	p-value
Normal	18 (52.9%)	25 (69.4%)	
Underweight	11 (32.4%)	7 (19.4%)	
Overweight/obese	5 (14.7%)	4 (11.1%)	0.043

Underweight was more frequent among vitamin D-deficient participants. Overall, nutritional status showed a statistically significant association with vitamin D status (p=0.043).

Table 7: Lifestyle and Dietary Factors Associated with Vitamin D Deficiency

Factor	Vitamin D deficient (n=34)	Non-deficient (n=36)	p-value
Outdoor activity <30 min/day	22 (64.7%)	12 (33.3%)	0.011
Outdoor activity ≥30 min/day	12 (35.3%)	24 (66.7%)	
Inadequate sunlight exposure	24 (70.6%)	14 (38.9%)	0.009
Adequate sunlight exposure	10 (29.4%)	22 (61.1%)	
Low dietary vitamin D intake	25 (73.5%)	17 (47.2%)	0.027
Adequate dietary intake	9 (26.5%)	19 (52.8%)	

Inadequate sunlight exposure, reduced outdoor activity, and low dietary vitamin D intake were significantly more common among participants with vitamin D deficiency.

Table 8. Clinical Features Suggestive of Impaired Bone Health

Clinical feature	Number (n=70)	Percentage (%)
Bone/musculoskeletal pain	16	22.9
Muscle weakness	10	14.3
Recurrent limb pain	13	18.6
History of fracture	5	7.1
Skeletal deformity	3	4.3

No significant bone-related symptoms	39	55.7
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Bone or musculoskeletal pain was the most frequently reported clinical feature, occurring in 22.9% of participants.

Table 9: Biochemical Parameters According to Vitamin D Status

Parameter	Vitamin D deficient (n=34)	Non-deficient (n=36)	p-value
Serum calcium (mg/dL)	8.72 ± 0.61	9.04 ± 0.48	0.018
Serum phosphorus (mg/dL)	3.72 ± 0.67	4.01 ± 0.59	0.061
Alkaline phosphatase (U/L)	268.5 ± 74.2	231.6 ± 65.8	0.031
25(OH)D (ng/mL)	14.2 ± 3.8	28.7 ± 9.6	<0.001

Vitamin D-deficient participants had significantly lower serum calcium and higher alkaline phosphatase levels compared with non-deficient participants. The difference in serum phosphorus was not statistically significant.

Table 10: Correlation of Serum 25(OH)D with Growth and Bone Health Parameters

Parameter	Correlation coefficient (r)	p-value
Weight	0.214	0.075
Height	0.268	0.025
BMI	0.182	0.131
Serum calcium	0.321	0.007
Serum phosphorus	0.196	0.103

Alkaline phosphatase	-0.346	0.003
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Serum 25(OH)D showed a significant positive correlation with height and serum calcium, while a significant negative correlation was observed with alkaline phosphatase. No significant correlation was observed with weight, BMI, or serum phosphorus.

Discussion

The present study evaluated 70 children and adolescents attending ESIC Medical College and Hospital to determine the prevalence of vitamin D deficiency and to assess its relationship with demographic characteristics, nutritional status, growth parameters, lifestyle factors, and indicators of bone health. The study demonstrated a substantial burden of suboptimal vitamin D status, with 48.6% of participants being vitamin D deficient and 30.0% being vitamin D insufficient.

The high prevalence observed in the present study is consistent with previous reports indicating that vitamin D deficiency is common among Indian children despite the country's generally favourable sunlight conditions. Marwaha et al. reported a high prevalence of vitamin D insufficiency among apparently healthy schoolchildren in Delhi, emphasising that adequate sunlight availability does not necessarily ensure adequate vitamin D status¹⁰. Similarly, Puri et al. reported widespread vitamin D insufficiency among apparently healthy children and adolescents in northern India¹¹.

In the present study, vitamin D deficiency was more common among males than females, although the difference was not statistically significant. Similar variations according to sex have been reported in pediatric studies, but the direction and magnitude of the association differ between populations. Differences in clothing, outdoor activity, dietary habits, and social practices may

influence vitamin D status and may explain some of these variations^{3,9}.

Age was also examined as a potential determinant. Vitamin D deficiency was somewhat more frequent among older children and adolescents. Adolescence represents a period of rapid skeletal growth and increased demand for calcium and vitamin D. At the same time, adolescents may spend less time outdoors because of academic activities and increased indoor screen-based activities. These factors may contribute to an increased risk of vitamin D deficiency during adolescence^{7,8}.

A significant association was observed between nutritional status and vitamin D deficiency in the present study. Underweight participants were more frequently vitamin D deficient than those with normal nutritional status. Nutritional inadequacy may contribute to insufficient intake of vitamin D and other nutrients required for healthy skeletal development. Conversely, vitamin D deficiency may coexist with broader nutritional deficiencies, particularly in children with inadequate dietary intake.

Lifestyle factors demonstrated an important relationship with vitamin D status. Participants with inadequate sunlight exposure and limited outdoor activity had significantly higher rates of vitamin D deficiency. This finding is biologically plausible because Ultraviolet-B exposure is essential for cutaneous synthesis of vitamin D. Holick has emphasized that inadequate exposure to sunlight is a major contributor to vitamin D deficiency worldwide³. Similarly, recommendations from the American Academy of Paediatrics recognise the importance of adequate vitamin D intake and appropriate preventive strategies during childhood¹².

Low dietary vitamin D intake was also significantly associated with deficiency in the present study. Dietary

sources of vitamin D are relatively limited, and inadequate consumption of vitamin D-containing or fortified foods can therefore contribute to deficiency. Dietary assessment is particularly relevant in children who have restricted dietary patterns or inadequate overall nutritional intake^{4,5}.

The study also evaluated growth parameters. Vitamin D-deficient participants had somewhat lower mean weight, height, BMI, and height-for-age Z-scores compared with non-deficient participants, although most differences did not reach statistical significance. Serum 25(OH)D demonstrated a significant positive correlation with height. These findings suggest a possible relationship between vitamin D status and growth, although the cross-sectional nature of the study does not permit establishment of a causal relationship. Growth is multifactorial and is influenced by genetics, nutrition, endocrine function, chronic disease, and socioeconomic factors in addition to vitamin D status.

Bone-related symptoms were relatively common among vitamin D-deficient children. Bone or musculoskeletal pain was the most frequently reported symptom, followed by recurrent limb pain and muscle weakness. Vitamin D deficiency can cause impaired mineralisation and may manifest with musculoskeletal symptoms even before overt clinical rickets develops^{5,6}. However, such symptoms are nonspecific and should be interpreted together with biochemical and clinical findings.

Biochemical evaluation demonstrated significant differences in serum calcium and alkaline phosphatase between vitamin D-deficient and non-deficient participants. Vitamin D-deficient children had lower mean serum calcium and higher alkaline phosphatase levels. Vitamin D deficiency reduces intestinal calcium absorption and may result in compensatory changes in

bone metabolism. Increased alkaline phosphatase reflects increased osteoblastic activity and is commonly observed in children with impaired bone mineralisation^{6,13}.

Serum 25(OH)D showed a significant positive correlation with serum calcium and a significant negative correlation with alkaline phosphatase. These findings support the physiological relationship between vitamin D status and mineral homeostasis. Similar biochemical alterations have been described in children with vitamin D deficiency and nutritional rickets^{5,6}.

The present study has important clinical implications. Because vitamin D deficiency was frequent among apparently growing children and was associated with modifiable lifestyle factors, routine attention to sunlight exposure, outdoor physical activity, dietary adequacy, and appropriate vitamin D supplementation may be beneficial. Early recognition is particularly important during childhood and adolescence because these periods provide an important opportunity to optimise peak bone mass.

The study has certain limitations. The sample size was relatively small, and the study was conducted at a single tertiary care centre, which may limit generalizability. The cross-sectional observational design also prevents determination of causal relationships between vitamin D status and growth or bone health. Dietary intake and sunlight exposure were assessed primarily through reported information and may therefore be subject to recall bias. Bone health assessment was predominantly clinical and biochemical, without comprehensive radiological or bone mineral density assessment in all participants.

Despite these limitations, the study provides useful information regarding the burden of vitamin D deficiency among children and adolescents and highlights the

importance of potentially modifiable determinants such as sunlight exposure, outdoor activity, and dietary intake.

Conclusion

The present study demonstrated a high prevalence of vitamin D deficiency (48.6%) among children and adolescents attending a tertiary care hospital. Inadequate sunlight exposure, reduced outdoor activity, and poor dietary vitamin D intake were important associated factors. Vitamin D deficiency was also associated with unfavourable biochemical indicators of bone health and showed a significant relationship with height and serum calcium levels. Early identification, adequate sunlight exposure, appropriate nutrition, and timely vitamin D supplementation may help improve vitamin D status and support healthy growth and skeletal development in children and adolescents.

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