



Original Article

Vitamin D deficiency in patients with cerebral palsy: A common entity

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ABSTRACT

Introduction: Cerebral palsy (CP) is a non-progressive neurological disorder with varied motor, sensory, and musculoskeletal impairments. Patients with CP are at high risk for low bone mineral density due to poor nutrition, reduced mobility, and antiepileptic drug (AED) use, contributing to vitamin D deficiency. This study aims to determine the prevalence of vitamin D deficiency and identify associated risk factors to improve bone health and overall outcomes in patients with CP.

Material and Methods: This prospective analytical study included 150 patients with CP aged 1-12 years, conducted at B.J. Medical College and Civil Hospital, Ahmedabad, from October 2022 - September 2024. Detailed clinical assessments, Gross Motor Function Classification System (GMFCS) scoring, laboratory tests (including serum vitamin D, calcium, phosphorus, and alkaline phosphatase), and relevant imaging were performed. Vitamin D levels were categorized as deficient, insufficient, or sufficient. Data were analyzed using Excel and statistical tests like Chi-square and Fisher's exact test.

Results: This study included 150 patients with CP, predominantly male (62%). The most common age group was 3-5 years, with spastic quadriplegia as the most frequent CP type (51.8%). Vitamin D deficiency was found in 52% of patients, significantly higher in non-ambulatory patients. Common co-morbidities included microcephaly, epilepsy, and global developmental delay.

Conclusion: This study emphasizes the high prevalence of vitamin D deficiency in patients with CP, particularly non-ambulatory types, highlighting the need for early supplementation, screening, nutritional support, and comprehensive management.

Keywords: Bone health, Cerebral palsy, GMFCS scale, Spastic quadriplegia, Vitamin D deficiency.

INTRODUCTION

Cerebral palsy (CP) represents a diverse group of non-progressive neurological disorders caused by brain injury or malformation during early development.¹ It primarily affects motor function and posture but is often accompanied by a wide range of complications, including sensory impairments, intellectual disabilities, epilepsy, and musculoskeletal disorders. These challenges vary in severity and presentation, making clinical management complex and lifelong.^{2,3}

One of the major but often overlooked complications in patients with CP is impaired bone health, particularly low bone mineral density (BMD). Patients with CP are at increased risk of developing low BMD due to poor nutritional intake, feeding difficulties, reduced mobility, delayed puberty, and frequent use of antiepileptic drugs (AEDs). These factors collectively contribute to bone

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demineralization, increasing the risk of fractures and growth impairment.

Vitamin D deficiency plays a central role in this scenario. It affects calcium absorption and bone mineralization and is frequently seen in patients with CP due to limited sun exposure (often being housebound), inadequate dietary intake, and the use of AEDs, which negatively impact vitamin D metabolism. Despite its known effects, vitamin D deficiency remains underdiagnosed and poorly managed in this population.

This hospital-based study aims to evaluate the prevalence of vitamin D deficiency in patients with CP and to assess its clinical implications, particularly in relation to BMD and associated risk factors. By investigating a cohort of pediatric Patients with CP, the study seeks to identify key nutritional, therapeutic, and lifestyle contributors to deficiency and to evaluate current supplementation practices. The findings will help guide targeted interventions to improve bone health and overall outcomes in patients living with CP.

MATERIAL AND METHODS

This prospective analytical study was conducted at the pediatric outpatient department (OPD) and ward of Civil Hospital, Ahmedabad, affiliated with B.J. Medical College, from 1 October 2022 - 30 September 2024, or until a sample size of 150 patients diagnosed with CP was reached. The primary objective of the study was to evaluate the prevalence and clinical impact of vitamin D deficiency in patients with CP at a tertiary care hospital.

A total of 150 patients aged 1-12 years who met the standard diagnostic criteria for CP were enrolled. The selection included patients from both outpatient and inpatient settings. A detailed clinical history and examination were conducted for each participant using a pre-structured proforma, and informed written consent was obtained from parents or guardians. The study received ethical approval from the Institutional Ethical Committee of B.J. Medical College and Civil Hospital, Ahmedabad.

Children were included if they were aged 1-12 years and diagnosed with CP. Exclusion criteria included children <1 year or >12 years, those with progressive neurological disorders (such as neurodegenerative or demyelinating diseases), patients without motor involvement, and those with renal or liver diseases, malabsorption syndromes, or a family history of metabolic bone disorders.

Clinical assessments included thorough central nervous system (CNS) examinations, as well as ophthalmological evaluations and hearing assessments using Brainstem

Evoked Response Audiometry (BERA). Motor function was graded using the Gross Motor Function Classification System (GMFCS), with levels I-III considered ambulatory and levels IV and V classified as non-ambulatory. Laboratory investigations comprised serum 25-hydroxyvitamin D [25(OH)D], calcium, phosphorus, and alkaline phosphatase levels. Radiological investigations, such as wrist X-rays, were performed when indicated to assess bone health. Neuroimaging and EEG were also conducted as required.

Vitamin D levels were categorized as deficient (≤ 12 ng/mL), insufficient (12–20 ng/mL), or sufficient (≥ 20 ng/mL).⁴ Data were recorded in Microsoft Excel and analyzed using appropriate statistical tools. Chi-Square test, Fisher's exact test, and Binomial test were used to assess the significance of associations between vitamin D status and various clinical variables. Results were summarized in frequency tables, and meaningful conclusions were drawn to guide further understanding and management of vitamin D deficiency in patients with CP.

RESULTS

In this study, out of 1,68,654 patients, there were 150 patients with CP >2 years. This contributes to 0.09% of total patients. Out of a total of 150 patients, 56 patients were enrolled from the OPD, and 94 patients were enrolled from the inpatient department (IPD). There was a relatively higher proportion of CP amongst hospitalized patients as compared to OPD patients. Out of 150 patients, 93(62%) were male, and 57(38%) were female. Thus, a preponderance of males was found. A *p* value of 0.003 indicates that there was a statistically significant difference between the observed distribution of males and females and the expected equal distribution. The most common age group for presentation of CP was 3-5 years (48%), followed by 1-3 years (42%), which was statistically significant (*p* value = 0.0006). According to the current study, 78.1% of patients were hospital delivered as compared to 21.8% home delivered, which was also found to be statistically significant (*p* value <0.005). Currently, 88.6% of deliveries occur in health facilities (according to NFHS 2019-2021).⁵ However, among the study population of patients with CP, 78.1% were hospital deliveries and 21.8% were home deliveries.⁶ Out of the total patients, 59% were born by vaginal delivery, 33.6% by caesarean section, and 7% were delivered by instrumental vaginal delivery.⁷ Although standard literature does not specifically address the association between the mode of delivery and the likelihood of CP, both planned and emergency caesarean sections can reduce the risk of hypoxic damage to the fetus. This is particularly relevant in the presence of maternal and fetal risk factors or signs of fetal distress, as these interventions can help prevent CP by minimizing neuronal insult from intra-partum asphyxia.⁸ The most common antenatal risk

factor for CP was pregnancy induced hypertension (PIH) (23.6%), followed by Antepartum hemorrhage and maternal age in extremes, each in 10% of cases. Perinatal asphyxia was the most common intra-natal risk factor for CP found in 41.8% of cases, followed by low birth weight (30%) and prematurity (23.6%).⁹ The most common postnatal risk factor was hypoxic ischemic encephalopathy (HIE) (24%), followed by septicemia, hypoglycemia, and CNS infection in 20%, 16.36%, and 13.6%, respectively. Thus, the current study observed birth asphyxia (41.8%) to be the most common risk factor among all.¹⁰

Table 1: Distribution of patients based on type of CP.

Type of CP	No of patients (n = 150)	Percentage (%)	Chi-square test (p value)
Spastic diplegic	38	25.4	<0.0001
Spastic quadriplegic	78	51.8	
Spastic hemiplegic	15	10.0	
Dystonic	9	6.3	
Hypotonic	7	4.5	
Ataxic	0	--	
Mixed	3	1.8	

CP: Cerebral palsy

Spastic quadriplegic CP was the most common type observed in 51.8%, followed by spastic diplegic (25.4%) and spastic hemiplegic CP (10.0%) (*p* value <0.05) [Table 1].

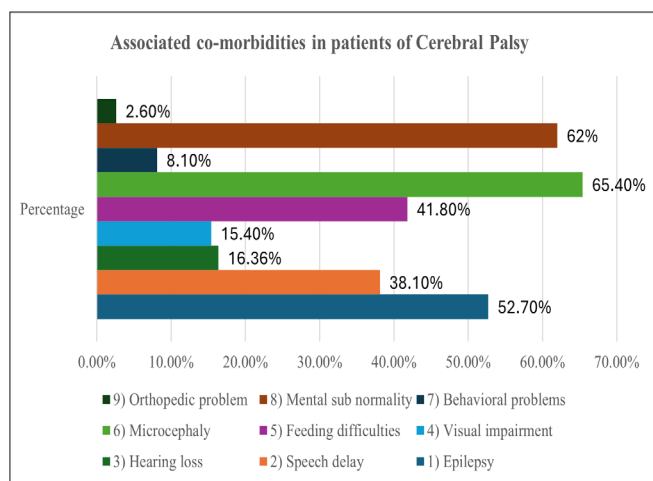


Figure 1: Associated co-morbidities in patients with CP.

Microcephaly was found to be the most common morbidity observed in 65.4%, followed by mental subnormality (62%), epilepsy (52.7%), and feeding difficulties (41.8%). Amongst the higher functions, speech delay was present in 38.1%, followed by hearing impairment in 16.36% and visual impairment in 15.4% of patients [Figure 1].

Table 2: Factors associated with subnormal vitamin D levels among patients with CP

Type of CP	Suboptimal vitamin D levels (n = 108) (%)	Chi-square test (p value)
Age in months		
< 60	97 (72)	<0.0001
≥ 60	11 (73)	0.027
Sex		
Male	65 (70)	<0.0001
Female	43 (75)	<0.0001
On vitamin D supplementation	3	1.8
No	88 (91.7)	<0.0004
Yes	20 (37)	0.012
GMFCS score for motor function		
Ambulatory	22 (44)	0.317
Non-ambulatory	86 (86)	<0.0001
Use of AED		
No	60 (85)	<0.0007
Yes	48 (61)	0.011
Duration of AED use		
<1 year	9 (27)	0.00057
≥1 year	28 (61)	0.061
Sun exposure		
≤ 1 hour	83 (89)	<0.0004
>1 hour	25 (44)	0.261
Feeding problems		
Yes		
No	63(73)	<0.0008

CP: Cerebral palsy GMFCS: Gross Motor Function Classification System
AED: Anti epileptic Drug. Suboptimal vitamin D levels: <20 ng/ml

Attention deficit disorder was diagnosed in 6, whereas 3 patients were suspected to have autistic spectrum disorder and were kept under follow-up for further evaluation. We observed Level V motor disability as the most common in 51.8%, followed by Level III in 21.7% of patients (*p* value <0.0009, which is <0.05). Fewer patients were in the less severe categories, with only 3.3% in Level I and 8.7% in Level II. This could be because ours is a tertiary care referral center dealing with more severe cases. It is shown that 44% of the patients with CP had normal serum calcium levels (8.4-10.4 mg/dL), while 56% suffered from hypocalcemia.

Regarding serum inorganic phosphate levels, 73.3% of the patients had normal levels (2.5-4.5 mg/dl). However, 21.3% had hypophosphatemia, and a smaller proportion (5.3%) had hyperphosphatemia. Serum ALP levels were found to be normal in 78.6% patients. We observed that only 28% of the patients had sufficient vitamin D levels (20-30 ng/mL). A significant proportion of the patients had inadequate vitamin D levels, with 20% having insufficiency (12-20 ng/mL) and 52% having deficiency (≤ 12 ng/mL). Additionally, 8% of the patients had severe vitamin D deficiency (≤ 5 ng/mL). Overall, 72% of the patients had subnormal vitamin D levels, highlighting a widespread prevalence of vitamin D deficiency among patients with CP, enforcing the importance of vitamin D supplementation in these patients.¹¹ The Chi-square test yielded a p value of <0.0001 , indicating that the differences in the distribution of vitamin D levels were highly statistically significant.

The analysis reveals that suboptimal vitamin D levels are common among patients with CP, affecting 72% of the study population. Key factors significantly associated with better vitamin D status include vitamin D supplementation, ambulatory status, and sun exposure of more than one hour daily. Patients receiving supplements or with higher mobility were more likely to have adequate levels. In contrast, non-ambulatory patients, those on AEDs, and those with limited sun exposure were at greater risk of deficiency. Age, sex, feeding problems, and serum calcium or phosphate levels showed no strong correlation with vitamin D status. These findings emphasize the importance of supplementation, physical activity, and adequate sun exposure in managing bone health in patients with CP [Table 2].

Association of AEDs with vitamin D status and bone health

Enzyme-inducing AEDs such as phenytoin, phenobarbitone, and carbamazepine increase hepatic metabolism of vitamin D and may adversely affect bone health. In this study, AED use was significantly associated with suboptimal vitamin D levels in patients with CP, with a higher prevalence among those receiving AEDs compared to non-users ($p = 0.011$). Longer duration of AED exposure was also associated with poorer vitamin D status, particularly in patients treated for ≥ 1 year. However, individual AEDs were not analysed separately, and bone mineral density was not directly assessed. Vitamin D status and biochemical parameters were used as surrogate markers; therefore, no specific enzyme-inducing AED could be implicated.

Calcium and vitamin D supplementation

Vitamin D supplementation was strongly associated with adequate vitamin D status: 63% of patients with adequate levels

were supplemented, whereas 91.7% of non-supplemented patients had suboptimal levels ($p = <0.0001$). Data on calcium supplementation were not recorded, and serum calcium levels could not reliably indicate supplementation practices.

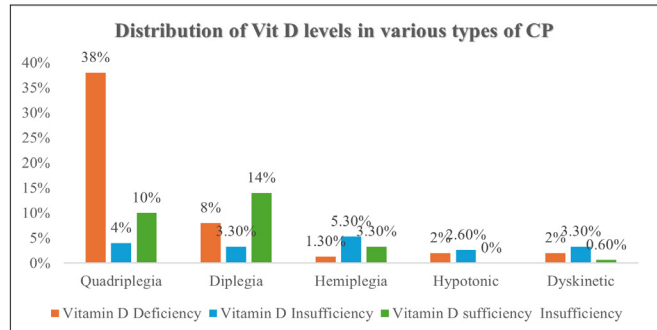


Figure 2: Distribution of vitamin D levels in various types of patients with CP.

When vitamin D levels were analyzed across different types of CP, it was found that Spastic quadriplegia had a high prevalence of vitamin D deficiency (38%). Spastic diplegia (25.3%) had a relatively higher proportion of patients with sufficient vitamin D levels (14%). Among hemiplegic, hypotonic, dyskinetic, and mixed CP types, most patients showed deficient or insufficient levels. The Chi-square test revealed a highly significant association ($p = 3.70 \times 10^{-9}$) between the type of CP and vitamin D status. Fisher's exact test further confirmed a strong association between CP type and suboptimal vitamin D levels, highlighting that patients with quadriplegia are particularly vulnerable to vitamin D deficiency.¹²

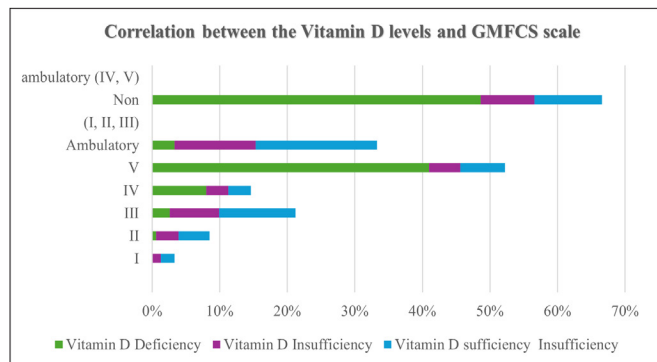


Figure 3: Correlation between the vitamin D levels and GMFCS scale.

This study demonstrated a strong correlation between the severity of motor impairment, as measured by GMFCS levels, and vitamin D status in patients with CP. Vitamin D deficiency increased significantly with higher GMFCS levels, with no deficiency seen in Level I and the highest rate (41%) in Level V. Ambulatory patients (GMFCS I–III) had better vitamin D levels, while non-ambulatory patients (GMFCS

IV and V) showed a much higher prevalence of deficiency. A Chi-square test (p value <0.0004) confirmed this association to be statistically significant, indicating that patients with severe motor impairment are at greater risk of vitamin D deficiency [Figure 3].¹³

All patients with CP received rehabilitation and physiotherapy.¹⁴ Over half (52.6%) were on anti-seizure medications, and 45.3% on muscle relaxants. Behavioral therapy and antipsychotics were required by 4% of patients, indicating limited psychological or behavioral issues. Vision problems were noted in 3.3% of patients, and 2.6% required either a foot prosthesis or VP shunt for hydrocephalus. None of the patients used hearing aids. Vitamin D supplementation was given to all the patients along with calcium and phosphorus supplementation. Overall, while core therapies were universally applied, other treatments were individualized based on specific clinical needs.

DISCUSSION

The present study highlights a high prevalence of vitamin D deficiency and related biochemical abnormalities among patients with CP. Over 70% of the patients had suboptimal vitamin D levels, with 52% deficient and 20% insufficient, aligning with findings from Kiriongi *et al.*¹¹ and Manohar *et al.*,¹³ though rates varied across studies. Hypocalcemia was observed in 56% of patients, while 73.3% had normal phosphate and 78.6% had normal alkaline phosphatase (ALP) levels. Vitamin D deficiency was strongly associated with non-ambulatory status (GMFCS IV and V), poor sun exposure, AED use, and lack of supplementation. In patients with CP, AED use, particularly prolonged therapy, was significantly associated with suboptimal vitamin D levels. While enzyme-inducing AEDs are biologically linked to impaired bone health, no specific AED could be identified in the present study. Suboptimal vitamin D levels were markedly more common in patients not receiving vitamin D supplementation, emphasizing the need for proactive supplementation strategies in this population. Among CP subtypes, spastic quadriplegia showed the highest rate of deficiency. Statistical analyses, including chi-square and Fisher's exact test, confirmed significant associations between vitamin D levels and clinical variables such as mobility, sun exposure, AED use, and CP type. Compared to prior studies, the present data align closely with those of Manohar *et al.*¹³ and Kiriongi *et al.*,¹¹ though variations likely reflect geographic, clinical, or diagnostic differences. The findings emphasize the importance of routine monitoring of vitamin D and bone-related markers in patients with CP, particularly those with severe motor impairment, to prevent complications like rickets, osteopenia, and fractures, and to support better mobility and overall health outcomes.

LIMITATIONS

Small sample size: The study's findings are based on a relatively small group of 150 patients from a single hospital, which may limit the generalizability of the results.

No control group: The absence of a control group makes it difficult to draw definitive causal inferences about the associations observed.

Short study duration: The 2-year study period may not capture long-term outcomes or the effects of interventions over time.

Focus on Vitamin D: The emphasis on Vitamin D deficiency overlooks other potential nutritional or environmental factors contributing to CP.

CONCLUSION

This study demonstrated a high prevalence of vitamin D deficiency (52%) and insufficiency (20%) among patients with CP, particularly in non-ambulatory individuals and those lacking sun exposure or supplementation. Significant associations were found between vitamin D status and clinical factors such as CP type, mobility level, and AED use. These findings underscore the urgent need for routine screening and vitamin D supplementation in high-risk CP populations to prevent bone health complications and improve functional outcomes.

Clinical significance

The clinical significance of this study lies in its demonstration of a high prevalence of vitamin D deficiency (52%) and insufficiency (20%) among patients with CP, particularly those with severe motor impairments (GMFCS levels IV and V), limited sun exposure, AED use, and no vitamin D supplementation. These patients are at increased risk of skeletal complications such as rickets, osteopenia, and pathological fractures, which can further compromise mobility and quality of life. The study also highlights that non-ambulatory status and spastic quadriplegic CP are strongly associated with suboptimal vitamin D levels. Routine monitoring of vitamin D and related biochemical markers (calcium, phosphate, ALP) is therefore essential in the clinical management of patients with CP. Early detection and targeted supplementation can help mitigate bone health issues, support musculoskeletal development, and potentially enhance physical functioning, making vitamin D assessment a vital component of comprehensive CP care.

Author contributions: SM: Concept, literature search, clinical studies, data acquisition, data analysis, statistical analysis, and manuscript preparation, editing, and review; AC: Review and editing, and supervision; JV: Supervision. All authors approve the final version of

the manuscript.

Ethical approval: The research/study was approved by the Institutional Review Board at B.J. Medical College & Civil Hospital, Ahmedabad, number 79/2023, dated 30/12/2023.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms from the patients' parents/guardians. In the form, they have given their consent for the patient's clinical information to be reported in the journal. They understand that the names and initials will not be published and due efforts will be made to conceal the patient's identity, but anonymity cannot be guaranteed.

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