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ORIGINAL ARTICLE

Vitamin D Levels, Lung Function, and Risk Factors in Paediatric Asthma: Evidence from a Case–Control Study

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Abstract

Introduction: Asthma is one of the commonest chronic respiratory disorders in children, influenced by environmental, perinatal, genetic, and nutritional factors. Vitamin D, has essential immunomodulatory functions apart from its role in bone health. Vitamin D has its implications in asthma pathogenesis and control. This study was conducted to assess the serum vitamin D levels in asthmatic and non-asthmatic children, and also to evaluate its correlation with lung function, and the role of associated risk factors. **Materials and Methods:** A hospital-based cross sectional, comparative study was conducted after obtaining Institutional Ethical committee approval. The study was conducted among 50 asthmatics and 50 age- and sex-matched non-asthmatic controls in the age group of 5–16 years. Baseline demographic and anthropometric data were recorded. The environmental risk factors perinatal history, familial history were obtained from the participants. Pulmonary function parameters (FVC, FEV1, FEV1/FVC, PEFR, $FEF_{25–75}$) were measured by spirometry following American Thoracic Society (ATS) guidelines. Serum vitamin D levels were determined using a standard immunoassay. Age-appropriate oral or written assent was obtained from the parents. **Results:** The results showed significantly lower mean vitamin D levels in asthmatic children (15.75 ± 4.46 ng/ml) when compared to controls (18.85 ± 3.98 ng/ml; $p < 0.001$). FEV1 and FEV1/FVC ratios were significantly decreased in asthmatic children ($p < 0.001$). Positive associations with asthma were observed in preterm birth babies ($p = 0.011$), parental history ($p = 0.026$), and passive smoking ($p < 0.001$). There was a significant positive correlation of vitamin D levels with FEV1/FVC ratio overall ($r = 0.473$), in controls ($r = 0.388$), and in cases ($r = 0.333$). **Conclusion:** Positive associations with asthma and lung function were observed with lower vitamin D levels. Addressing the vitamin D deficiency along with modifiable risk factors such as passive smoking may improve the control of asthma. Further research are warranted to establish the therapeutic and preventive role of vitamin D deficiency in childhood asthma.

Keywords: Asthma, Vitamin D, Lung function, Children, Passive smoking

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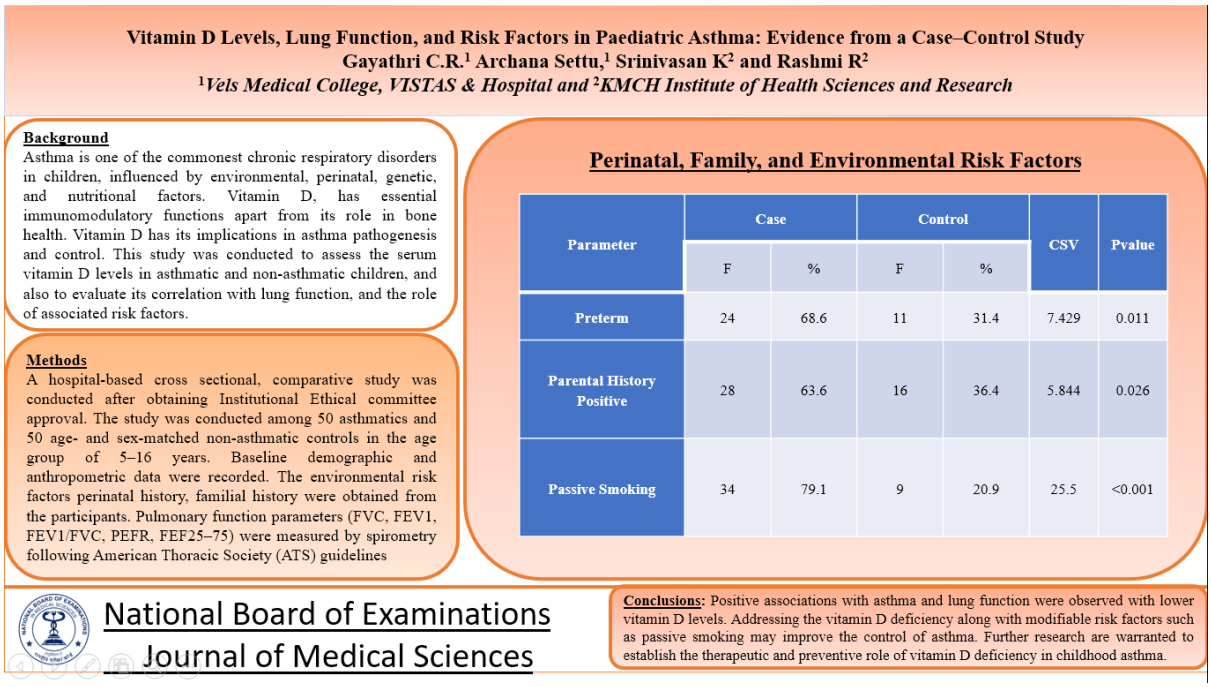
Graphical Abstract



Introduction

Asthma is one of the most prevalent chronic respiratory disorders in children and it has significant public health concern all over the world. It is characterized by the airway obstruction, airway inflammation and bronchial hyperresponsiveness. The prevalence of asthma has been rising recently, mainly among children, leading to severe health morbidity, and impaired quality of life [1,2]. Worldwide, it is estimated that over 300 million people are affected, and childhood asthma contributes substantially to disability-adjusted life years lost due to respiratory disorders [3]. The prevalence of asthma in children ranges between 2–20%, with regional variations, and it has various challenges in early diagnosis, treatment adherence, and environmental risk factor modification [4].

Vitamin D is known for its role in calcium and bone metabolism, and it has recently gained attention for its immunomodulatory properties. The receptors of Vitamin D are widely expressed on T lymphocytes, B lymphocytes, macrophages, and dendritic cells, suggesting its influence on both adaptive and innate immunity [5]. Recent researchers have proved that vitamin D may decrease the airway inflammation, improve epithelial integrity, and enhance regulatory T-cell function, which are relevant to the pathogenesis of asthma [6,7]. Vitamin D deficiency has been linked with increased risk to respiratory infections, wheezing, and lesser asthma control in children [8].

Various studies have suggested an association between low serum vitamin D levels and increased asthma severity, its exacerbations, and decreased pulmonary function parameters, particularly FEV1 and FEV1/FVC ratios [9,10]. Vitamin D deficiency has also been linked with elevated steroid resistance in asthmatics, highlighting its role in influencing the treatment outcomes [11]. There are evidences which prove this association, but there is a paucity of regional studies from India, where both asthma and vitamin D deficiency are highly prevalent due to

different lifestyles, limited sun exposure an urbanization.[12].

The current study was undertaken to assess the serum vitamin D levels in asthmatic and non-asthmatic children and to evaluate their association with lung function parameters. The study also explored perinatal, familial, and environmental risk factors for asthma, with an emphasis on the role of parental history, passive smoking, and preterm birth. These associations may provide insights into the interplay between nutritional status of children and asthma. This may help in building preventive and therapeutic strategies for Indian asthmatic children.

Aim and Objectives

1. To compare the pulmonary function parameters, and Vitamin D levels between Asthmatic and Non-Asthmatic Children
2. To correlate the serum Vitamin D levels with FEV1/FVC ratio in cases and controls
3. To evaluate the association of perinatal, family, and environmental risk factors with childhood asthma.

Materials and Methods

This hospital-based cross sectional, comparative study was conducted after obtaining Institutional Ethical committee approval. The study was conducted among 50 asthmatics and 50 age- and sex-matched non-asthmatic controls in the age group of 5–16 years. The cases were identified in the inpatient department and paediatric outpatient after taking spirometry, confirmation of asthma based on clinical history, physical examination in accordance with GINA guidelines. The controls were age- and sex-matched healthy children without a history of asthma or other respiratory disorders. Exclusion criteria include children receiving long-term steroids for conditions other than asthma, chronic systemic illnesses or those with congenital anomalies.

For children below 7 years of age, only *parental/guardian consent* was obtained prior to recruitment, as they were considered too young to provide meaningful assent. For those aged 7–11 years, *oral assent* was obtained in addition to parental consent, while for children aged 12 years and above, *written assent* was taken along with parental consent.

Basic demographic and anthropometric details like age, sex, weight, height and body mass index (BMI), were obtained from the participants. Family history of asthma, perinatal history, environmental exposures such as passive smoking were recorded.

Lung function parameters were assessed using spirometry in accordance with American Thoracic Society (ATS) recommendations. The parameters measured included Forced Vital Capacity (FVC), Forced Expiratory Volume in the first second (FEV1), FEV1/FVC ratio, Forced Expiratory Flow between 25–75% of vital capacity (FEF25–75) and Peak Expiratory Flow Rate (PEFR) were recorded. The best of three reproducible manoeuvres was taken from each participant, and calibration of the spirometer was performed daily.

Under aseptic precautions, venous blood samples were collected for estimating serum vitamin D levels in the participants. Chemiluminescent immunoassay (CLIA) or equivalent validated methods, was used as a standard immunoassay method and adherence to internal quality control protocols was ensured in the institution's central laboratory [13,14].

All the data were entered into a database and analysed using standard statistical methods. Continuous variables (age, BMI, lung function parameters, vitamin D levels) were expressed as mean ± standard deviation. It was then used to compare the cases and controls using independent sample T-tests. Chi-square test was used to assess the categorical variables (preterm birth, parental history, passive smoking exposure). Pearson's correlation coefficient was used to evaluate the correlation between serum vitamin D levels and pulmonary function indices. p-value <0.05 was considered statistically significant (Figure 1).

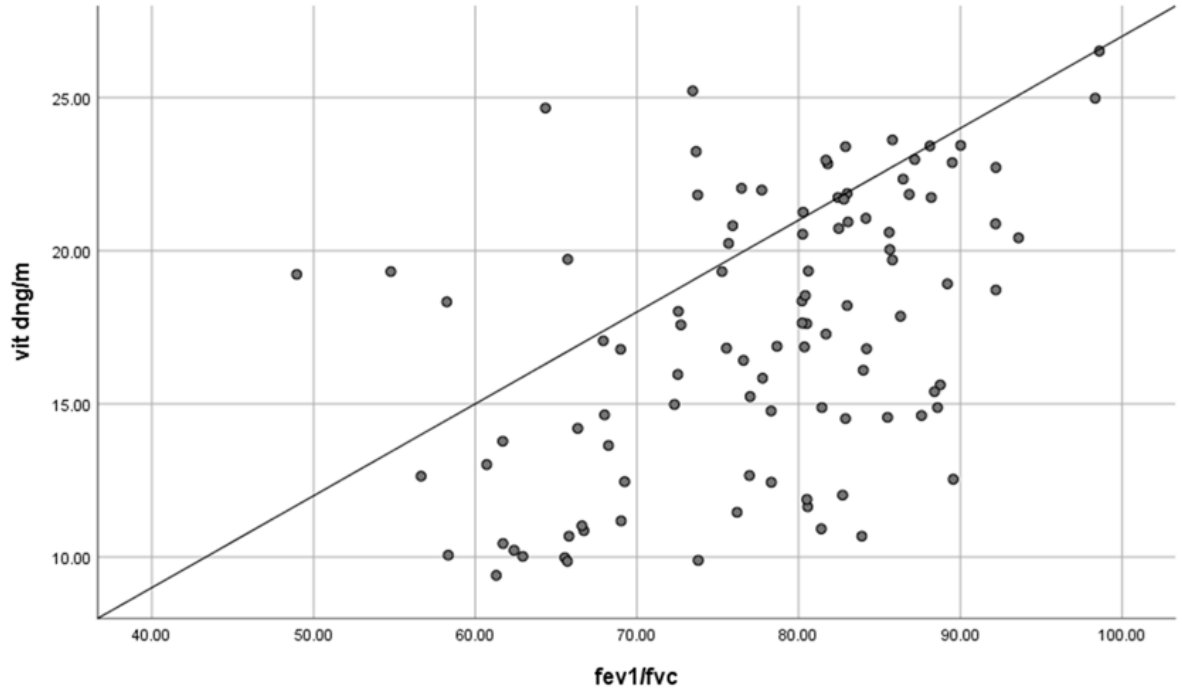


Figure 1. Correlation of Serum Vitamin D Levels with FEV1/FVC Ratio in Cases and Controls

Results

The study included 50 asthmatics (cases) and 50 non-asthmatics (controls). The mean age of the participants was 10.28 ± 2.73 years, with no significant difference between the cases (10.14 ± 2.88) and the controls (10.42 ± 2.58). Similarly, height and weight did not differ significantly across groups. However, the mean Body Mass Index (BMI) was found to be significantly higher among the cases (19.50 ± 2.13) when compared to the non-asthmatics (18.27 ± 2.86), with a mean difference of 1.23 (p = 0.02).

Spirometry revealed that FVC values were comparable between groups. In contrast, FEV1 values were markedly decreased in the asthmatics (1.48 ± 0.42) compared to the non-asthmatics (1.84 ± 0.49), which was significant (p < 0.001) statistically. The FEV1/FVC ratio showed a pronounced difference, with asthmatic children demonstrating much lower ratios (69.87 ± 7.68) compared to controls (85.54 ± 4.58), giving a significant difference (p < 0.001). Peak Expiratory Flow Rate (PEFR) was also significantly decreased in asthmatics (2.81 ± 0.57) than in controls (3.39 ± 0.95) (p < 0.001). But, the mean values of

FEF25–75 were not significantly different between cases and controls. Serum vitamin D levels were considerably lesser among the cases (15.75 ± 4.46 ng/ml) when compared to controls (18.85 ± 3.98 ng/ml), with a mean difference of 3.10, which was considered to be highly significant ($p < 0.001$) statistically (Table 1).

Table 1. Comparison of General Characteristics, Pulmonary Function Parameters, and Vitamin D Levels between Asthmatic and Non-Asthmatic Children

Parameter	Overall				Case		Control		MD	t Value	P Value
	Min	MaX	Mean	SD	Mean	SD	Mean	SD			
Age	5	16	10.28	2.73	10.14	2.88	10.42	2.58	0.28	0.511	0.28
Height	107	170	139.34	15.04	138.70	16.27	139.98	13.85	1.28	0.424	0.67
Weight	18	64	37.61	10.90	36.56	10.51	38.66	11.29	2.10	-0.963	0.34
BMI	14.40	24.40	18.88	2.59	19.50	2.14	18.27	2.86	1.23	-2.438	0.02
FVC	1.030	4.230	2.15	0.61	2.15	0.65	2.16	0.58	0.01	0.083	0.93
FEV1	0.86	2.77	1.66	0.49	1.48	0.42	1.84	0.49	0.37	3.984	<0.001
FEV1/ FVC	48.96	98.60	77.70	10.08	69.87	7.69	85.54	4.58	15.67	12.379	<0.001
PEFR	1.16	5.24	3.10	0.83	2.81	0.57	3.39	0.95	0.58	3.729	<0.001
FEF 25-75	0.700	3.880	1.99	0.58	2.01	0.66	1.97	0.49	0.04	-0.349	0.728
Vit D ng/mL	9.40	26.52	17.30	4.49	15.75	4.46	18.85	3.98	3.10	3.657	<0.001

Associated risk factors also faced significant differences between cases and controls. Preterm birth was more commonly observed among the cases, with 68.6% of cases reporting a preterm history as against only 31.4% of controls, a difference that was statistically significant ($\chi^2 = 7.429$, $p = 0.011$).

A positive parental history of asthma was also more common in asthmatics (63.6%) compared to non-asthmatics (36.4%) ($\chi^2 = 5.844$, $p = 0.026$). While looking at the environmental risk factors, the exposure to passive smoking was found to be higher in the cases, with 79.1% whereas only 20.9% of controls were exposed. This association was highly significant ($\chi^2 = 25.5$, $p < 0.001$). These findings highlight that perinatal factors, family history, and passive smoking act as strong contributors to the development of asthma in children (Table 2).

Table 2. Association of Perinatal, Family, and Environmental Risk Factors with Asthma

Parameter	Case		Control		CSV	Pvalue
	F	%	F	%		
Preterm	24	68.6	11	31.4	7.429	0.011
Parental History Positive	28	63.6	16	36.4	5.844	0.026
Passive Smoking	34	79.1	9	20.9	25.5	<0.001

The correlation analysis between pulmonary function and serum vitamin D levels, measured by the FEV1/FVC ratio, showed a significant positive relationship. In this research, the correlation coefficient was r = 0.473, indicates a moderate positive correlation. When analysed separately, the correlation remained statistically significant in both groups, though with varying strength. Among the non-asthmatics, the correlation was r = 0.388, whereas among the asthmatics, it was r = 0.333. This positively suggest that the higher vitamin D levels are associated with better pulmonary function across all paediatric age group, and that this positive link is seen in asthma as well.

Discussion

In the current research, the children with asthma had significantly lesser serum vitamin D levels compared to non-asthmatic controls. This is similar with various earlier reports that proved a strong relationship between hypovitaminosis D and asthma susceptibility in children [8–10]. Vitamin D has a pivotal role in immunomodulation, particularly in regulating T-cell proliferation, epithelial barrier integrity, and dendritic cell activity. [5–7]. Vit D deficiency may lead to airway inflammation, increased severity by causing bronchospasm, thereby explaining the lesser vit D levels observed among the cases.

The Spirometry parameters revealed that FEV1 and FEV1/FVC ratios reduction in cases compared to controls, with expected pathophysiological changes in the obstructive airway disease [1–3]. Serum vit D levels showed a positive association with pulmonary function indices (overall r = 0.473), implying that adequate vit D may help to maintain the lung function. Similar findings were reported by Gupta et al. [10], who showed that lower vit D levels were associated with more airway remodelling and lessened lung function in asthmatic group. Brehm et al. [8] also emphasized that vit D deficiency was associated with increased risk of severe asthma exacerbations, proving the protective role of vit D in respiratory health. Also, Fedora et al. [15] in a meta-analysis reported that vit D supplementation lessens the asthma exacerbations in children and may cause improvements in FEV1, further strengthening the clinical relevance of our findings.

There exists significant association of asthma with factors such as preterm birth, positive parental history of asthma, perinatal history, and passive smoking. Preterm babies are known to have under developed lungs and altered immune responses, predisposing them to chronic respiratory illness like asthma [2,4]. A positive family history suggests the genetic predisposition, while exposure to passive smoking suggests the contribution of modifiable environmental triggers [3,4]. Our study agrees with the past researches which stated that family history and environmental exposures play an essential role in determining the asthma risk in children [4,12].

The immunological basis of relationship between the vit D deficiency and asthma is further supported by the studies showing that vitamin D role in regulatory T- cell function and reduces airway hyperresponsiveness [5,6]. Pfeffer and Hawrylowicz [7] reported the importance of vit D in maintaining pulmonary health, particularly in children with a high prevalence of vit D deficiency. Searing et al. [11], reported that the decreased vit D levels have been linked to poor response to corticosteroid therapy, which proves the asthmatic children with low vitamin D have poorer control and more frequent exacerbations. Recent

systematic reviews and expert opinions continue to emphasize this dual role. In the Cochrane review, during the year 2023 by Williamson et al. [16], the vitamin D supplementation may decrease the risk of severe exacerbations, although heterogenous results were obtained world wide. Devulapalli [17] had showed in a 2025 study, that supplementation can be beneficial in some children, but it does not consistently improve the pulmonary function across all populations.

The results of our study underscore the multifactorial nature of paediatric asthma, involving the genetic susceptibility, environmental exposures, perinatal influences, and nutritional status. The current study adds to the fact that the role of vit D in the pathophysiology of asthma, highlights the need for routine evaluation of vitamin D levels in asthmatic children, especially in developing countries like India where vit D deficiency is common [12]. Treatment of vit D deficiency, with avoidance of passive smoke exposure and careful monitoring of preterm children or with positive parental history, could provide a more comprehensive strategy for the prevention and management of asthma. Further researches, ie., randomized trials in children, must be initiated to begin vitamin D supplementation for improved clinical outcomes in pediatric asthma, which is evident from recent systematic reviews [15–17].

Conclusion

The current study showed that the asthmatic children had significantly lesser serum vit D levels compared to non-asthmatics. The decreased vitamin D levels was positively correlated with impaired pulmonary function tests, particularly FEV1 and the FEV1/FVC ratio. The perinatal and environmental risk factors like preterm birth, positive parental history of asthma, and passive smoking were found to be positively associated with asthma. These findings show the multifactorial involvement of paediatric asthma, where both environmental and genetic determinants interact with nutritional status to influence the asthmatic disease expression.

The results highlight the role of vitamin D as a modifiable risk factor in paediatric asthma. Routine screening for vit D deficiency, dietary supplementation or lifestyle interventions, and by preventing environmental triggers such as passive smoking may together contribute to better control and prevention of paediatric asthma. Further interventional and longitudinal studies are needed to establish whether the targeted vitamin D supplementation can improve clinical outcomes and pulmonary function in children with asthma.

Statements and Declarations

Conflicts of interest

The authors declare that they do not have conflict of interest.

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