

## EXPLORING THE ASSOCIATION BETWEEN VITAMIN D LEVELS AND ASTHMA SEVERITY: A COMPREHENSIVE ANALYSIS

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### Abstract

**Background:** Asthma is a prevalent chronic respiratory condition characterized by airway inflammation and heightened airway reactivity. Recent investigations suggest a potential association between low levels of vitamin D and the severity of asthma. This study aims to explore the relationship between vitamin D levels and various asthma symptoms, including pulmonary function, severity, and exacerbation rates, in individuals diagnosed with the condition. **Materials and Methods:** A cohort of 100 individuals diagnosed with asthma, aged between 18 and 65 years, was assembled for this study. Vitamin D levels were categorized as inadequate (<20 ng/mL), insufficient (20-29 ng/mL), and sufficient ( $\geq$ 30 ng/mL). Asthma severity was assessed based on clinical criteria, and exacerbation rates and lung function tests (predicted FEV1%) were documented. Statistical analyses, including logistic regression, were conducted to assess the correlation between vitamin D levels and asthma severity. **Result:** Vitamin D deficiency was prevalent among individuals with severe asthma (88%), whereas those with mild asthma exhibited higher proportions of sufficient vitamin D levels (52.5%). Participants with deficient vitamin D levels experienced significantly elevated exacerbation rates and lower FEV1 percentages compared to those with sufficient levels ( $p < 0.01$ ). Logistic regression analysis indicated that for every 10 ng/mL increase in vitamin D levels, there was a 60% decrease in the odds of having severe asthma (OR: 0.4, 95% CI: 0.22-0.72,  $p = 0.002$ ). **Conclusion:** Our findings suggest a robust correlation between vitamin D levels and pulmonary function, asthma severity, and exacerbation rates. Adequate vitamin D levels may contribute to improved clinical outcomes and reduced asthma severity. Further research is warranted to fully elucidate the therapeutic implications and molecular mechanisms of vitamin D supplementation in asthma management.

## INTRODUCTION

Asthma continues to be a major public health concern worldwide, impacting millions of people and putting a tremendous strain on healthcare systems.<sup>[1]</sup> Characterized by chronic inflammation and airway hyper-responsiveness, asthma is a complex respiratory condition with multi-factorial etiology and diverse clinical presentations. Despite advancements in treatment modalities, achieving optimal asthma control and reducing exacerbation rates remain ongoing challenges.<sup>[2]</sup>

In recent times, there has been a growing curiosity surrounding the role of vitamin D in both the

progression and management of asthma. The immunomodulatory qualities of vitamin D and its possible impact on respiratory health have drawn attention, despite its primary involvement in calcium homeostasis and bone health.<sup>[3,4]</sup> More research into the potential therapeutic applications of vitamin D insufficiency has been spurred by epidemiological studies that have linked it to higher rates and severity of asthma.<sup>[5]</sup>

The possible connection between vitamin D and asthma has been explained by a number of different processes. Asthma airway inflammation may be influenced by vitamin D, which is known to control immunological responses, including the generation of anti-inflammatory cytokines and T-cell function

modification.<sup>[6]</sup> Furthermore, vitamin D has been linked to the preservation of smooth muscle contractility and the integrity of the airway epithelium, two functions that are disrupted in the pathogenesis of asthma.<sup>[7]</sup>

This study aims to fill a knowledge gap by thoroughly exploring the association between Vitamin D levels and asthma outcomes in a cohort of people diagnosed with the condition. By shedding light on Vitamin D's role in asthma pathophysiology, this research has the potential to guide future approaches to personalized asthma care and therapeutic interventions aimed at enhancing Vitamin D status to enhance patient outcomes.

## MATERIALS AND METHODS

**Study Design:** A prospective cohort design is used to evaluate the relationship between Vitamin D levels and asthma outcomes in people who had been diagnosed with asthma. The study was conducted at the spanning from January 2023 to December 2023.

**Study Population:** The study included individuals aged 18 to 65 years diagnosed with asthma, recruited from the outpatient department of the respiratory medicine. Participants were selected based on clinical diagnosis and confirmed spirometry results indicative of asthma. Exclusion criteria included individuals with other significant respiratory conditions, chronic systemic diseases affecting Vitamin D metabolism,<sup>[8]</sup> and those unwilling to participate.

**Data Collection:** Participants underwent comprehensive clinical evaluations, including medical history assessment, physical examination, and spirometry testing, to confirm asthma diagnosis and assess disease severity. Demographic information such as age, gender, and BMI was recorded. Serum Vitamin D levels were measured from the collected blood samples using standardized assays. Asthma severity was categorized based on clinical criteria, including symptom frequency, medication requirements, and spirometry results.

**Exacerbation Monitoring:** Participants were followed up regularly throughout the study period to monitor asthma exacerbations. Exacerbations were characterized as sudden worsening of asthma symptoms necessitating treatment with systemic corticosteroids, visits to the emergency department, or hospital admissions. Exacerbation rates were calculated based on the number of exacerbations per participant-year.

**Pulmonary Function Testing:** Spirometry was conducted during initial and subsequent visits to evaluate pulmonary function. The forced expiratory volume in one second (FEV1) was assessed as a percentage of expected values to gauge airflow restriction and the severity of the disease.

**Statistical Analysis:** The relationship between vitamin D levels and asthma outcomes was investigated using proper statistical approaches.

Vitamin D levels and participant characteristics were compiled using descriptive statistics. After correcting for relevant confounders such as age, gender, BMI, and smoking status, bivariate and multivariate analyses were conducted to investigate the link between vitamin D level and asthma severity, exacerbation rates, and pulmonary function.

**Ethical Considerations:** Ethical approval was granted from the Institutional Ethics committee of the, prior to study commencement. Informed consent was obtained from all participants before enrollment, and confidentiality of participant data was maintained throughout the study.

## RESULTS

### Study Population Characteristics

In our study, 100 people with an average age of 35 who were diagnosed with asthma and ranged in age from 18 to 65. 40% of the population was male and 60% was female. Upon analyzing the participants' Body Mass Index (BMI), it was found that 5% were underweight (less than 18.5 kg/m<sup>2</sup>), 45% were normal weight (18.5-24.9 kg/m<sup>2</sup>), 30% were overweight (25-29.9 kg/m<sup>2</sup>), and 20% were obese (more than 30 kg/m<sup>2</sup>).

### Vitamin D Levels and Distribution

The subjects' vitamin D level was categorized as follows: Three quarters of the population had inadequate vitamin D levels (20–29 ng/mL) with an average of 25 ng/mL, thirty percent had appropriate vitamin D levels ( $\geq 30$  ng/mL) with an average of 35 ng/mL, and thirty percent were deficient in vitamin D (<20 ng/mL).

### Asthma Severity Assessment

According to the study cohort's estimate of the severity of their asthma, 40% of individuals had mild asthma, 35% had moderate asthma, and 25% had severe asthma.

### Association Between Vitamin D Levels and Asthma Severity

The following shows the distribution of asthma severity based on vitamin D status:

Out of the individuals with severe asthma, 88% had inadequate levels of Vitamin D, 12% had insufficient levels, and none had sufficient levels.

Twenty-one percent of participants with mild asthma had inadequate levels of vitamin D, forty percent had good levels, and seventeen percent had poor levels.

Vitamin D deficiency affected 5% of people with mild asthma, insufficient levels affected 42.5%, and sufficient levels affected 52.5%.

### Exacerbation Rates and Pulmonary Function

The average number of exacerbations per year differed considerably across the groups based on Vitamin D status: individuals with low levels had an average of four exacerbations, those with inadequate levels had two, and those with adequate levels had an average of one (p=0.01).

Pulmonary function, as measured by FEV1 percentage of anticipated, was likewise linked to

vitamin D levels. An average FEV1 of 60% of expected values was seen in those with a shortage in Vitamin D, 75% in those with insufficient levels, and 85% in those with sufficient levels ( $p < 0.001$ ).

### Statistical Analysis

The probability of developing severe asthma dropped by 60% with every 10 ng/mL increase in vitamin D levels, according to a logistic regression study that took age, gender, BMI, and smoking status into consideration (Odds Ratio: 0.4, 95%).  $p = 0.002$ , Confidence Interval: 0.22-0.72).

**Table 1: Study Population Characteristics**

Characteristic	Percentage (%)	Notes
Gender		
Female	60	
Male	40	
Age Range	18-65	Mean Age: 35 years
BMI Categories		
Underweight (<18.5)	5	
Normal (18.5-24.9)	45	
Overweight (25-29.9)	30	
Obese ( $\geq 30$ )	20	

**Table 2: Vitamin D Levels and Distribution**

Vitamin D Status	Participants (n)	Percentage (%)	Average Vitamin D Level (ng/mL)
Deficient (<20)	30	30	15
Insufficient (20-29)	35	35	25
Sufficient ( $\geq 30$ )	35	35	35

**Table 3: Asthma Severity Assessment**

Asthma Severity	Participants (n)	Percentage (%)
Mild	40	40
Moderate	35	35
Severe	25	25

**Table 4: Association Between Vitamin D Levels and Asthma Severity**

Vitamin D Status	Mild Asthma (n)	Moderate Asthma (n)	Severe Asthma (n)
Deficient (<20)	2	6	22
Insufficient (20-29)	17	15	3
Sufficient ( $\geq 30$ )	21	14	0

**Table 5: Exacerbation Rates and Pulmonary Function by Vitamin D Status**

Vitamin D Status	Annual Exacerbation Rate	Average FEV1 (% of predicted)
Deficient (<20)	4	60
Insufficient (20-29)	2	75
Sufficient ( $\geq 30$ )	1	85

**Table 6: Statistical Analysis of Vitamin D Levels on Asthma Severity**

Analysis Type	Outcome	Statistical Significance
Logistic Regression Analysis	Each 10 ng/mL increase in Vitamin D level	OR: 0.4, 95% CI: 0.22-0.72, $p=0.002$

## DISCUSSION

This study significantly improves our understanding of the complex relationship between vitamin D levels and asthma outcomes. Our results, supported by higher exacerbation rates and impaired pulmonary function in individuals with low vitamin D levels, clearly illustrate a strong correlation between vitamin D deficiency and increased asthma severity. These findings align with previous research, strengthening the understanding of vitamin D's critical role in regulating airway inflammation and immune responses, which are crucial factors in the development of asthma.<sup>[9]</sup>

**Mechanistic Insights:** The observed correlation between Vitamin D deficiency and exacerbated asthma severity can be elucidated through various

intricate mechanistic pathways. Vitamin D, a secosteroid hormone, exerts profound regulatory effects on immune function, orchestrating a delicate balance between pro-inflammatory and anti-inflammatory responses within the respiratory system.<sup>[10,11]</sup>

**Immunomodulation:** Vitamin D is essential for modifying immunological responses, especially in the context of asthma. T cells, dendritic cells, and macrophages are among the immune cells that express vitamin D receptors (VDRs).<sup>[12]</sup> Following its binding to Vitamin D receptors (VDRs), vitamin D stimulates the production of anti-inflammatory cytokines such as interleukin-10 (IL-10), while simultaneously inhibiting the secretion of pro-inflammatory cytokines like interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF- $\alpha$ ). This intricate

regulatory network helps attenuate airway inflammation, a hallmark feature of asthma pathology, thereby mitigating disease severity.<sup>[13]</sup>

**Epithelial Integrity:** Vitamin D directly affects airway epithelial cells, which are essential for maintaining the integrity of the airway and the operation of the barrier. By increasing the production of tight junction proteins like occludin and claudin, vitamin D strengthens the integrity of the epithelial barrier and reduces the amount of allergens and pathogens that can enter the airway lumen. Additionally, vitamin D promotes the synthesis of antimicrobial peptides that provide innate protection against respiratory infections, such as cathelicidin and defensins.<sup>[14]</sup> By bolstering airway epithelial integrity and innate immune defenses, Vitamin D helps mitigate airway hyperresponsiveness and reduce susceptibility to asthma exacerbations.<sup>[15]</sup>

**Smooth Muscle Tone:** Vitamin D exerts direct effects on airway smooth muscle tone, influencing bronchomotor tone and airway reactivity.<sup>[16]</sup> Vitamin D receptors are expressed on airway smooth muscle cells, where Vitamin D promotes the synthesis of contractile proteins and inhibits the production of pro-inflammatory mediators. Moreover, Vitamin D enhances intracellular calcium homeostasis within smooth muscle cells, thereby modulating bronchial smooth muscle contractility and relaxation. By regulating airway smooth muscle tone, Vitamin D helps alleviate airway hyperresponsiveness, a hallmark feature of asthma exacerbations.<sup>[17]</sup>

**Clinical Implications:** Our findings hold significant implications for clinical practice, offering a promising avenue for optimizing asthma management strategies. Detecting and remedying Vitamin D deficiency among asthma patients emerges as a compelling strategy for ameliorating disease severity and curbing exacerbation risk. Clinicians are urged to consider routine screening for Vitamin D deficiency, particularly among patients exhibiting suboptimal symptom control or recurrent exacerbations, and contemplate Vitamin D supplementation as an integral component of a multifaceted treatment approach.

**Study Strengths and Limitations:** This study's strengths lie in its prospective design, comprehensive evaluation of asthma outcomes, and meticulous adjustment for potential confounding variables during statistical analysis. However, inherent limitations, including the observational nature of the study, susceptibility to residual confounding, and the potential for reverse causation, warrant acknowledgment. Additionally, the generalizability of our findings may be somewhat constrained by the study's specific population and setting.

## CONCLUSION

Our research highlights the significant link between asthma severity and vitamin D levels, offering fresh insights into the potential therapeutic advantages of

vitamin D supplementation in asthma management. These discoveries pave the way for tailored treatments aimed at enhancing asthma control and improving patient outcomes by elucidating the molecular foundation and practical ramifications of vitamin D deficiency in asthma.

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