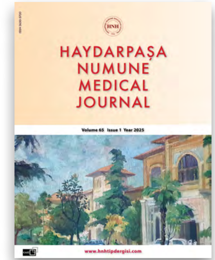
HAYDARPAŞA NUMUNE MEDICAL JOURNAL

DOI: 10.14744/hnhj.2025.28482
Haydarpasa Numune Med J 2025;65(4):384–388

ORIGINAL ARTICLE



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Vitamin D and Asthma: Association with Pulmonary Function and Eosinophilic Inflammation

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Abstract

Introduction: Asthma is a chronic inflammatory airway disease marked by variable airflow obstruction and bronchial hyperresponsiveness. Vitamin D, known for its immunomodulatory properties, has been suggested to influence asthma pathophysiology, potentially affecting pulmonary function and eosinophilic inflammation. This study aims to investigate the differences in vitamin D levels between asthmatic patients and healthy individuals, and to analyze the correlation of vitamin D with pulmonary function, arterial oxygen saturation, and eosinophilic inflammation markers.

Methods: This retrospective observational study reviewed medical records from 147 asthmatic patients and 30 healthy controls at a research hospital from January 2022 to January 2023. Pulmonary function tests, arterial oxygen saturation, and eosinophilic markers (eosinophil count, eosinophil percentage, total immunoglobulin E (IgE), and eosinophil cationic protein (ECP) levels) were analyzed.

Results: No significant difference in vitamin D levels was observed between asthmatic patients and healthy controls ($p=0.543$). A weak positive correlation was found between vitamin D levels and peak expiratory flow (PEF)% ($r=0.185$, $p=0.025$). No significant correlations were observed between vitamin D levels and other pulmonary function parameters or eosinophilic markers.

Discussion and Conclusion: While vitamin D levels did not differ significantly between asthmatic and healthy individuals, a weak positive correlation with PEF% suggests a potential role in improving expiratory flow. No significant association was found with other pulmonary functions or eosinophilic inflammation markers. Further studies are needed to clarify the role of vitamin D in asthma management.

Keywords: Asthma; eosinophil cationic protein; immunoglobulin E; lung function tests; Vitamin D.

Asthma is a long-term inflammatory disorder of the airways, marked by intermittent airflow impairment, increased bronchial responsiveness, and airway remodeling [1]. Despite advancements in treatment options, it continues to pose a substantial global health challenge, affecting roughly 300 million people and contributing significantly to healthcare resource use [2,3]. Beyond environmental and genetic influences, vitamin D has emerged as a possible modulator of asthma due to its immune regulatory effects [4].

Vitamin D contributes to the regulation of innate and adaptive immunity. Its deficiency has been linked to heightened airway inflammation and greater vulnerability

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Submitted Date: 13.05.2025 **Revised Date:** 22.09.2025 **Accepted Date:** 29.09.2025
Haydarpaşa Numune Medical Journal

to respiratory tract infections [5,6]. Prior research has associated lower vitamin D levels with more severe asthma, frequent exacerbations, and increased airway reactivity [7,8]. It may also influence eosinophilic responses and allergy-related biomarkers like total immunoglobulin E (IgE) [9]. However, studies examining its relationship with lung function in asthma have yielded inconsistent results [10,11].

This study sought to determine whether vitamin D concentrations differ between asthmatic patients and healthy individuals and to explore possible correlations between vitamin D levels and pulmonary function, oxygenation, and eosinophilic markers in asthmatic patients.

Materials and Methods

This study was approved by the Clinical Research Ethics Committee of Univesity of Health Sciences, Istanbul Fatih Sultan Mehmet Training and Research Hospital (approval no: FSM EAH-KAEK 2023/88, decision date: 25 May 2023). The study was conducted in accordance with the Declaration of Helsinki. Patient records from asthmatic individuals and healthy controls attending routine check-ups between January 1, 2022, and January 1, 2023, were reviewed. Only stable asthma patients not experiencing exacerbations and without comorbidities were included.

Vitamin D levels were compared across groups. Additionally, associations between vitamin D and lung function [Forced vital capacity (FVC), FVC%, forced expiratory volume in 1 second (FEV_1), FEV_1%, FEV_1/FVC, peak expiratory flow (PEF), PEF%], oxygen saturation ($SatO_2$), eosinophil count and percentage, total IgE, and eosinophil cationic protein (ECP) levels were analyzed.

Data from healthy controls lacked IgE and ECP levels due to the retrospective nature of the study. All data were anonymized, and access was limited to the study team.

Statistical Analysis

Data analysis was performed using IBM SPSS version 26.0. Numerical variables were summarized using descriptive statistics, and normality was assessed through tests such as Shapiro-Wilk and Kolmogorov-Smirnov. Depending on data distribution, either Pearson or Spearman correlation tests were used. Group comparisons employed the Independent Samples t-test or Mann-Whitney U test as appropriate. Categorical variables were compared using the Chi-square test. A p-value <0.05 indicated statistical significance.

Results

The study involved 147 asthmatic patients (Group I) and 30 healthy controls (Group II). Gender distribution did not differ significantly (p=0.512) (Table 1). Age, asthma duration, and vitamin D levels also showed no gender-based differences (Table 2).

No significant correlations were found between vitamin D levels and FVC, FVC%, FEV_1, FEV_1%, FEV_1/FVC, or PEF. However, vitamin D levels were weakly correlated with PEF% (r=0.185, p=0.025) (Table 3, Fig. 1). Mean serum vitamin D levels increased across PEF (%) groups, being 20.3±9.3 ng/mL in patients with PEF < 80%, 23.4±8.9 ng/mL in those with PEF 80–100%, and 26.7±13.2 ng/mL in patients with PEF > 100% (Table 4).

No significant correlations were observed between vitamin

Table 1. Gender distribution between the groups

	Group I (n=147)	Group II (n=30)	p
Gender (n, %)			0.512[a]
Female	104 (58.8)	23 (13.0)	
Male	43 (24.3)	7 (4.0)	

[a]: Pearson's Chi-square test.

Table 2. Patients with asthma

Gender	Female (n=104)	Male (n=43)	p
Age (years)	41±11	40±12	0.597[b]
Duration of asthma (years)	9.50±9.90	8.00±10.20	0.228[c]
Vitamin D levels	23.65±9.36	22.00±8.96	0.325[b]

[b]: Independent samples t test; [c]: Mann-Whitney U test.

Table 3. Correlation between lung function parameters and vitamin D levels

	n	Pearson correlation coefficient (r)	p
FVC	147	-0.094	0.258
FVC%	147	0.086	0.303
FEV_1	147	-0.078	0.348
FEV_1%	147	0.078	0.351
FEV_1/FVC	147	0.007	0.929
PEF	147	0.037	0.659
PEF%	147	0.185	0.025*

*: Statistically significant. FVC: Forced vital capacity; FEV_1: Forced expiratory volume in 1 second; PEF: Peak expiratory flow.

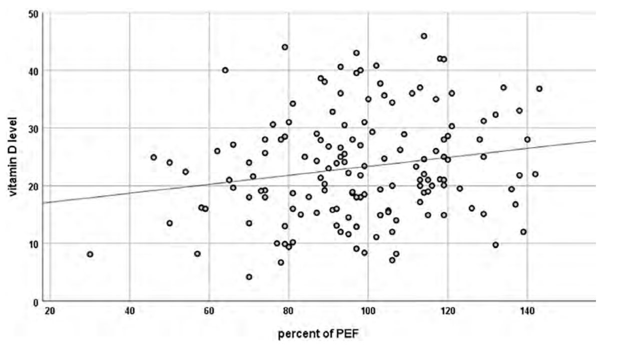

Figure 1. Correlation of PEF% with vitamin D levels of patients with asthma.
PEF: Peak expiratory flow.

Table 4. Vitamin D levels according to PEF (%) groups

PEF (%) group	Mean Vitamin D (ng/mL)±SD[b]	n
<80	20.3±9.3	33
80–100	23.4±8.9	53
>100	26.7±13.2	68

PEF: Peak expiratory flow; SD: Standard deviation.

Table 5. Correlation between eosinopil counts, total IgE, ECP and vitamin D levels

	n	Spearman's rho	p
Eosinophils/mm^3	137	0.101	0.238
Eosinophil %	136	0.154	0.074
Total IgE[a] (IU/mL)	121	0.150	0.099
ECP[b] (mcg/L)	102	-0.45	0.652

IgE: Immunoglobulin E; ECP: Eosinophil cationic protein.

Table 6. Eosinophil counts/mm^3 and eosinophil percentage of the groups

	Group I (n=137)	Group II (n=29)	p
Eosinophil/mm^3			[c]0.035*
Median	180.0	100.0	
%95 CI Level for median	160.0–210.0	100.0–200.0	
Mean±SD	226.8±190.0	157.0±88.5	
Min-max (range)	10.0–1240.0 (1230.0)	42.7–400.0 (357.3)	
%25-%75 perc	120.0–270.0	100.0–200.0	
Eosinophil %			[c]0.004*
Median	2.75	1.70	
%95 CI level for median	2.40–3.30	1.60–2.50	
Mean±SD	3.47±2.54	2.24±1.26	
Min-max (range)	0.10–16.10 (16.00)	0.70–6.30 (5.60)	
%25-%75 perc	1.90–4.25	1.30–2.80	

[c]: Mann-Whitney U Test; *: Statistically significant. CI: Confidence interval; SD: Standard deviation

Table 7. Vitamin D levels of the groups

	Group I (n=147)	Group II (n=30)	p
Vitamin D level			[b]0.543
Mean±SD	23.17±9.25	24.54±11.45	
Median	22.00	25.35	
%95 CI level for median	20.30–24.60	16.70–31.00	
Min-max (range)	4.19–45.90 (41.71)	5.62–45.60 (39.98)	
%25-%75 perc	16.00–28.60	15.80–32.00	

[b]: Independent samples t test. CI: Confidence interval; SD: Standard deviation.

D and eosinophil count, percentage, IgE, or ECP levels (Table 5). Eosinophil counts and percentages were significantly elevated in asthmatics compared to controls (Table 6). Vitamin D levels did not differ significantly between groups (Table 7), nor did they differ when grouped by $SatO_2$% (Table 8).

Discussion

This study examined the relationship between serum vitamin D concentrations and pulmonary function, eosinophilic inflammation, and allergic markers among individuals with asthma. Our analysis revealed no statistically significant difference in vitamin D levels between asthmatic patients and healthy controls. This contrasts with findings from previous research, which demonstrated lower vitamin D levels in asthmatic populations compared to non-asthmatic adults [12]. Similarly, Bai et al. [13] reported decreased vitamin D levels in children diagnosed with asthma compared to healthy peers.

Vitamin D has been the subject of considerable investigation in asthma due to its immunomodulatory potential [14,15]. Existing literature proposes that vitamin D deficiency could be linked to increased asthma severity and diminished lung function, likely through mechanisms involving airway inflammation and remodeling [16,17]. Nevertheless, our study did not establish a significant correlation between vitamin D levels and fundamental lung function metrics such as FEV_1 and FVC, with the exception of a weak yet statistically significant positive correlation with PEF%. This modest association may point to a limited but potential role of vitamin D in enhancing expiratory airflow, though further studies are necessary to confirm this finding.

Our results align with those of Mehrabi et al. [18], who also observed no significant connection between vitamin D deficiency and pulmonary function indicators. Conversely, a large-scale study involving 435,040 asthmatic individuals

Table 8. Vitamin D Levels in asthmatic patients (Group I) categorized by $SatO_2$%

$SatO_2$ %	97 (n=1)	98 (n=41)	99 (n=31)	p
Vitamin D				^{c}0.316
Median	25.56	21.00	23.30	
%95 CI level for median	19.00–35.00	18.90–27.00	18.50–25.50	
Mean±SD	27.00±8.77	21.83±9.32	23.13±9.30	
Min-max (range)	16.00–43.00 (27.00)	4.19–42.00 (37.81)	7.10–40.80 (33.70)	
%25-%75 perc	19.00–35.00	15.70–29.00	14.90–26.60	

$SatO_2$: Oxygen saturation; CI: Confidence interval; SD: Standard deviation.

found that higher vitamin D levels were associated with improved FVC, FEV_1, and FEV_1/FVC ratios [19]. Likewise, a meta-analysis conducted by Liu et al. [20] suggested a positive, albeit statistically insignificant, association between vitamin D and parameters such as FEV_1/FVC and FVC%. Additionally, Tamašauskienė et al. [21] reported significantly lower vitamin D levels in asthmatic adults compared to healthy individuals, though no meaningful relationship was found between vitamin D levels and lung function, IgE concentrations, or eosinophil counts. In our cohort, no significant correlations were observed between serum vitamin D levels and FEV_1 or FVC values; however, mean vitamin D concentrations increased progressively across PEF (%) groups, suggesting a potential link between higher vitamin D status and better expiratory performance.

Eosinophilic inflammation is a hallmark feature of asthma pathophysiology. Consistent with this understanding, our data demonstrated significantly elevated eosinophil counts and percentages in the asthma group compared to controls. Although previous studies proposed that vitamin D could reduce eosinophilic airway inflammation, potentially by downregulating IL-5, our analysis did not reveal a significant correlation between vitamin D levels and eosinophil counts or percentages [22]. Some publications have described an inverse association between vitamin D and eosinophil counts [12], yet this was not reflected in our findings. Furthermore, we did not identify any significant relationship between vitamin D levels and total IgE or ECP. While Mohammadzadeh et al. [23] reported a strong negative correlation between vitamin D and IgE in pediatric asthma patients, and similar associations have been described in adults [12], other studies found no such link [17]. Regarding ECP, Lu et al. [24] demonstrated in a cell culture study that vitamin D deficiency led to elevated levels of ECP and other eosinophil-related mediators, including eosinophil peroxidase, eosinophil-derived neurotoxin, and major basic protein.

Several limitations of our study should be noted. First, its retrospective design prevents the establishment of causality. Second, the limited size of the healthy control group may have impacted the ability to detect minor differences in vitamin D status. Third, variables such as dietary habits, ultraviolet exposure, and genetic factors influencing vitamin D metabolism were not considered, all of which may contribute to individual variability.

Conclusion

In summary, our findings do not support a strong association between vitamin D levels and key pulmonary function indicators or eosinophilic inflammation in asthmatic patients. Although a weak positive correlation was identified between vitamin D and PEF%, further longitudinal and controlled studies with larger sample sizes are necessary to fully elucidate the role of vitamin D in the pathophysiology and clinical management of asthma.

Ethics Committee Approval: The study was approved by the University of Health Sciences Istanbul Fatih Sultan Mehmet Training and Research Hospital Ethics Committee (No: FSM EAH-KAEK 2023/88, Date: 25.05.2023).

Use of AI for Writing Assistance: No artificial intelligence–based tools, including large language models, conversational systems, or image-generation technologies, were employed at any stage of this study, from its conception and execution to data analysis and manuscript preparation.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept – M.E., İ.K.; Design – M.E., İ.K.; Supervision – M.E., İ.K.; Fundings – M.E., İ.K.; Materials – M.E., İ.K.; Data collection and/or processing – M.E., İ.K.; Analysis and/or interpretation – M.E., İ.K.; Literature search – M.E., İ.K.; Writing – M.E., İ.K.; Critical review – M.E., İ.K.

Conflict of Interest: None declared.

Financial Disclosure: The authors declare that this research received no specific grant from any funding agency, commercial, or not-for-profit sectors.

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