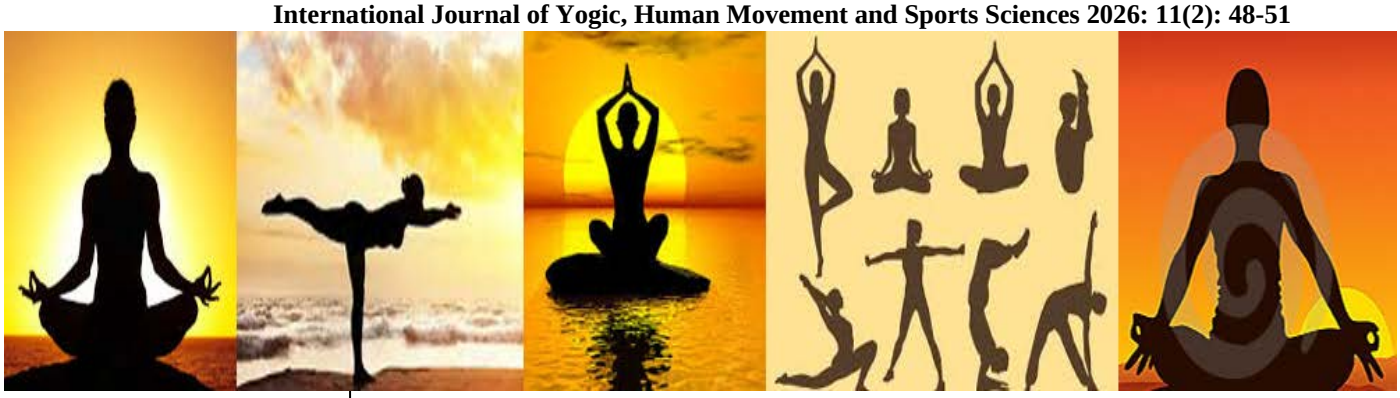
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Effects of adjunctive therapeutic yoga on pulmonary function and inflammatory markers in young adults with asthma

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Abstract
Background: Asthma is a chronic inflammatory airway disorder characterized by variable airflow limitation and bronchial hyperresponsiveness. Although pharmacological management remains the cornerstone of treatment, many individuals continue to experience persistent inflammatory activity and symptom burden. Therapeutic yoga has been proposed as an adjunctive intervention; however, evidence using objective pulmonary and inflammatory outcomes in young adults remains limited.
Objective: To evaluate the effects of adjunctive therapeutic yoga on pulmonary function and inflammatory biomarkers in young adults with asthma.
Methods: This controlled pilot study enrolled young adults with physician-diagnosed stable mild–moderate asthma. Participants were allocated to either (i) medication plus therapeutic yoga or (ii) medication alone (control). The yoga group received a structured program for 12 weeks, practiced 5 days per week. Spirometric indices forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and peak expiratory flow rate (PEFR) and inflammatory markers absolute eosinophil count (AEC) and erythrocyte sedimentation rate (ESR) were assessed before and after the intervention. Appropriate parametric and non-parametric statistical tests were applied, with significance set at $p<0.05$.
Results: No statistically significant between-group differences were observed in spirometric indices over the intervention period. Within the yoga group, significant reductions were observed in AEC ($p = 0.047$) and ESR ($p = 0.024$). Post-intervention ESR differed significantly between groups ($p = 0.041$), favoring the yoga group.
Conclusion: A 12-week therapeutic yoga program practiced 5 days per week was associated with significant reductions in inflammatory markers without corresponding short-term improvements in spirometric indices. These findings suggest that therapeutic yoga may exert beneficial anti-inflammatory effects in asthma. Larger randomized controlled trials with longer follow-up and patient-reported outcomes are warranted.

Keywords: Asthma, therapeutic yoga, pranayama; spirometry, FEV_1, FVC, PEFR, eosinophils, ESR

Introduction
Asthma is a chronic inflammatory disorder of the airways characterized by recurrent episodes of wheeze, dyspnea, chest tightness, and cough. The disease is associated with bronchial hyperresponsiveness, airway inflammation, and variable airflow limitation. Despite advances in pharmacological therapy, including inhaled corticosteroids and bronchodilators, many individuals continue to experience persistent symptoms, inflammatory activity, and impaired quality of life. Objective assessment of asthma severity and control commonly relies on spirometric indices such as forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and peak expiratory flow rate (PEFR).
Given the limitations of medication alone, there has been growing interest in complementary and integrative approaches that address the multidimensional nature of asthma. Therapeutic yoga is a structured mind–body intervention that integrates physical postures (asana), regulated breathing techniques (pranayama), and relaxation or meditation practices. These components may influence respiratory mechanics, autonomic regulation, stress physiology,

and inflammatory pathways processes that are all relevant to asthma pathophysiology. However, existing studies are heterogeneous in methodology, and robust evidence using objective pulmonary and inflammatory outcomes, particularly in young adults, remains limited.

The present pilot study was undertaken to explore the effects of adjunctive therapeutic yoga on both pulmonary function and inflammatory biomarkers in young adults with asthma receiving standard pharmacological treatment. The central hypothesis was that therapeutic yoga, when practiced regularly, may modulate inflammatory activity and respiratory physiology through combined mechanical, autonomic, and biochemical mechanisms.

Mechanistic Rationale

Therapeutic yoga may influence asthma outcomes through an integrated mechanical–autonomic–biochemical pathway. Asana-based practices emphasizing thoracic expansion, spinal alignment, and gentle mobilization may improve chest wall compliance and thoraco-diaphragmatic coordination. Improved posture and mobility can reduce reliance on accessory respiratory muscles, decrease breathing effort, and facilitate more effective lung expansion. These mechanical effects are most closely aligned with improvements in FVC, reflecting enhanced lung volume recruitment, and may secondarily influence FEV_1 when airflow limitation is partly related to inefficient breathing mechanics. Improved expiratory muscle coordination and confidence during forced expiration may also support PEFR performance.

Pranayama, or regulated breathing, may act through both autonomic rebalancing and airway biochemical modulation. Slow, controlled breathing with prolonged exhalation has been shown to shift autonomic balance toward parasympathetic dominance, reducing stress-related sympathetic arousal that can exacerbate breathlessness perception and bronchial reactivity. Pranayama also addresses dysfunctional breathing patterns, such as rapid shallow breathing and breath-holding under stress, thereby improving ventilatory control and reducing variability in respiratory effort.

Importantly, nasal breathing practices commonly emphasized in pranayama may enhance the delivery of nitric oxide (NO) from the paranasal sinuses into the lower airways. Nitric oxide is a biologically active gas involved in airway smooth muscle regulation, ventilation–perfusion matching, host defense, and inflammatory signaling. Although therapeutic yoga is not a substitute for pharmacological therapy, the combined effects of slower respiratory rate, nasal airflow, and improved airway conditioning may contribute to more stable airway behavior, potentially reflected as more consistent PEFR and gradual changes in FEV_1 over longer intervention periods.

Relaxation and meditation components of therapeutic yoga may further influence asthma through the stress–immune axis. Guided relaxation practices can downregulate hypothalamic–pituitary–adrenal (HPA) axis activity, reduce anxiety-driven hyperventilation, and diminish stress-mediated inflammatory signaling. By lowering chronic stress load and improving emotional regulation, therapeutic yoga may reduce eosinophilic activation and systemic inflammation, providing a plausible pathway for reductions in absolute eosinophil count (AEC) and erythrocyte sedimentation rate (ESR), even in the absence of short-term spirometric change.

Aim

To evaluate whether adjunctive therapeutic yoga improves pulmonary function and reduces inflammatory markers compared with medication alone in young adults with asthma.

2. Methods

2.1 Study Design

This study employed a controlled, parallel-group pilot design with pre- and post-intervention assessment.

2.2 Participants

Inclusion criteria

- Age 20–40 years
- Physician-diagnosed mild to moderate asthma
- Stable on asthma medication for at least four weeks prior to enrollment
- Baseline spirometry consistent with reversible airflow obstruction

Exclusion criteria

- Smoking history greater than 5 pack-years
- Presence of other chronic respiratory diseases
- Regular yoga practice prior to enrollment

2.3 Group Allocation

Participants were allocated into two groups:

1. Medication plus Therapeutic Yoga (Yoga Group)
2. Medication only (Control Group)

2.4 Intervention: Therapeutic Yoga Program

Participants in the yoga group underwent a structured therapeutic yoga protocol for 12 weeks, practiced 5 days per week, under the supervision of a trained yoga therapist.

Session structure

- Duration: 45–60 minutes per session
- Asana module: chest-opening postures, thoracic mobility exercises, and postural alignment practices
- Pranayama module: slow breathing techniques emphasizing nasal breathing and prolonged exhalation
- Relaxation/meditation: guided relaxation such as body awareness or yoga nidra

The control group continued their usual medical care without structured physical or yoga-based intervention.

2.5 Outcome Measures

2.5.1 Spirometry

FEV_1, FVC, and PEFR were measured at baseline and post-intervention using calibrated spirometry equipment in accordance with ATS/ERS guidelines. The best of three acceptable maneuvers was recorded. FEV_1 and FVC were expressed as absolute volumes in liters.

2.5.2 Inflammatory Biomarkers

Peripheral venous blood samples were collected for the assessment of absolute eosinophil count (AEC) and erythrocyte sedimentation rate (ESR).

2.5.3 Demographic and Anthropometric Data

Age, height, and weight were recorded at baseline.

2.6 Statistical Analysis

Data were analyzed using SPSS version 26. Normality was

assessed using the Shapiro–Wilk test. Parametric tests (paired and independent t-tests) or non-parametric alternatives (Wilcoxon signed-rank test and Mann–Whitney U test) were applied as appropriate. Statistical significance was set at $p<0.05$.

3. Results

3.1 Participant Characteristics

Table 1: Baseline demographics and anthropometrics (Mean ± SD)

Variable	Medication + Yoga	Medication only
Age (years)	40.6±7.043	38.4±12.02
Height (cm)	157.7±7.409	158.0±5.249
Weight (kg)	68.8±10.922	68.1±11.958

3.2 Pulmonary Function Outcomes

Table 2: Spirometry outcomes pre- and post-intervention (Mean ± SD)

Outcome	Group	Baseline	Post	p-value
FEV_1 (L)	Medication + Yoga	0.67±0.161	0.726±0.17	0.184
	Medication only	0.675±0.098	0.683±0.12	0.878
FVC (L)	Medication + Yoga	0.709±0.132	0.795±0.155	0.102
	Medication only	0.67±0.117	0.76±0.11	0.035*
PEFR	Medication + Yoga	4.99±9.258	0.602±0.238	0.646
	Medication only	0.487±0.205	0.569±0.252	0.167

Between-group comparisons revealed no statistically significant differences at baseline or post-intervention for spirometric variables.

3.3 Inflammatory Biomarkers

Table 3: Inflammatory biomarkers pre- and post-intervention (Mean ± SD)

Variable	Comparison	p-value
AEC	Within-group (Medication + Yoga)	0.047 (*)
AEC	Within-group (Medication only)	0.284 (ns)
AEC	Between-group at baseline (Mann–Whitney U)	0.185 (ns)
AEC	Between-group post-intervention (Mann–Whitney U)	0.363 (ns)
ESR	Within-group (Medication + Yoga)	0.024 (*)
ESR	Within-group (Medication only)	0.575 (ns)
ESR	Between-group at baseline (Mann–Whitney U)	0.423 (ns)
ESR	Between-group post-intervention (Mann–Whitney U)	0.041 (*)

Significant reductions in AEC and ESR were observed within the yoga group. Post-intervention ESR differed significantly between groups, favoring the yoga group.

4. Discussion

This pilot study evaluated the effects of a 12-week, 5-days-per-week therapeutic yoga intervention as an adjunct to standard pharmacological management in young adults with asthma. The principal finding was a significant reduction in inflammatory markers AEC and ESR in the yoga group, whereas spirometric indices did not demonstrate statistically significant short-term improvement.

A plausible interpretation is that inflammatory modulation may precede measurable changes in airflow parameters, particularly in stable asthma and over relatively short intervention periods. Improvements in inflammatory status may contribute to longer-term disease control, reduced exacerbation risk, and enhanced symptom stability, even in the absence of immediate spirometric change. These findings underscore the importance of evaluating both physiological and inflammatory domains when assessing adjunctive interventions in asthma.

5. Conclusion

A 12-week therapeutic yoga program practiced 5 days per week was associated with significant reductions in inflammatory markers in young adults with asthma, without significant short-term improvement in spirometric indices. Therapeutic yoga may serve as a valuable adjunctive strategy targeting inflammatory and stress-related mechanisms in asthma. Larger randomized controlled trials incorporating longer follow-up and multidimensional clinical outcomes are recommended.

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