

## Original Article

# HIIT as a Safe and Effective Exercise Modality for Improving Pulmonary Function and Exercise Tolerance in Individuals with Asthma

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## Abstract;

**Background** – Asthma is a chronic inflammatory disorder affecting millions globally, with symptoms including wheezing, chest tightness, and shortness of breath. Regular physical activity can mitigate these symptoms; however, the effectiveness and safety of HIIT for asthmatics remain underexplored. This study addresses this gap by examining HIIT's impact on asthmatic individuals, focusing on pulmonary function, FeNO levels (an inflammation marker), and exercise tolerance.

## Materials and Methods

Fourteen adult males, divided into asthmatic (n=7) and healthy control (n=7) groups, underwent a two-week HIIT protocol. Pulmonary function was assessed using peak expiratory flow (PEF), forced vital capacity (FVC), and forced expiratory volume in one second (FEV1/FVC ratio). FeNO was measured with a portable device, and exercise tolerance was evaluated through a progressive exercise test on a cycle ergometer to determine peak oxygen uptake (VO<sub>2</sub>peak), carbon dioxide output (VCO<sub>2</sub>peak), ventilation (VE), and time to exhaustion (TTE). Statistical analysis was performed using ANOVA with repeated measures.

## Results

The results indicated significant differences between groups in FeNO, VO<sub>2</sub> peak, TTE, and peak work rate (WR), with no significant changes in pulmonary function measures. Asthmatics showed a marked improvement in TTE and peak WR post-HIIT, with mean FeNO levels and pulmonary function measures remaining unchanged from baseline. Specifically, post-HIIT, asthmatics achieved higher VE, VCO<sub>2</sub>, TTE, and peak WR, demonstrating improved exercise tolerance and ventilation without exacerbating lung inflammation.

## Conclusion

HIIT was well-tolerated by individuals with asthma, leading to significant improvements in exercise tolerance and ventilation without negatively impacting pulmonary function or increasing lung inflammation. These findings suggest HIIT as a safe and effective exercise modality for asthmatics, potentially aiding in better asthma management through enhanced physical

fitness and exercise capacity.

**Key words:** High Intensity Interval Training (HIIT), Asthma, Pulmonary Function, Exercise Tolerance, Fractional Concentration of Exhaled Nitric Oxide (FeNO), Ventilation

## INTRODUCTION –

Asthma is a prevalent chronic inflammatory disorder of the airways, characterized by various cellular involvements such as mast cells, eosinophils, T-lymphocytes, B-lymphocytes, macrophages, neutrophils, and epithelial cells. These cells contribute to the symptoms commonly associated with asthma, including wheezing, chest tightness, shortness of breath, and coughing, affecting nearly 300 million individuals globally across all age groups, ethnicities, and regions (1). The condition not only imposes a significant health burden but also contributes to nearly 250,000 premature deaths annually worldwide (1). Urban populations exhibit a higher prevalence of asthma compared to rural counterparts, potentially due to differences in physical activity levels and environmental allergen exposures, although the exact reasons remain to be fully elucidated (1).

The role of regular physical activity in mitigating the development and exacerbation of asthma symptoms is well-documented, with the type, severity of asthma, and the intensity and duration of the activity being key factors influencing outcomes (2). High-Intensity Interval Training (HIIT), characterized by short bursts of intense exercise followed by periods of rest or low-intensity exercise, has emerged as a promising modality for improving health outcomes in asthmatic individuals. Despite the potential benefits, the safety and efficacy of HIIT for individuals with asthma have not been extensively investigated (2).

This study aims to bridge this knowledge gap by exploring the effects of HIIT on pulmonary function, exercise tolerance, and lung inflammation, as indicated by the fractional concentration of exhaled nitric oxide (FeNO), in both asthmatic and healthy individuals. FeNO levels, which increase in response to lung inflammation, serve as a diagnostic tool for asthma management, making it a pertinent measure for assessing the impact of HIIT on asthmatic subjects (3). By comparing changes in FeNO levels, pulmonary function, and exercise tolerance before and after a structured HIIT protocol, this research contributes valuable insights into the suitability of HIIT as a safe and effective exercise intervention for individuals with asthma.

## Materials and Methods:

### Study Design and Subjects-

This study employed a controlled experimental design to examine the effects of High Intensity Interval Training (HIIT) on asthmatic and healthy adult males. A total of fourteen participants were recruited and divided into two groups: asthmatics (ASTH; n=7) and healthy controls (CON; n=7). Inclusion criteria for the asthmatic group included a clinical diagnosis of asthma, whereas healthy controls had no history of respiratory or cardiovascular diseases. Exclusion criteria for all participants included smoking, cardiovascular disease, other cardiopulmonary conditions, and current participation in regular cardiovascular exercise routines.

### HIIT Protocol-

Participants underwent a two-week HIIT regimen consisting of six sessions. Each session included an 8-minute warm-up of loadless cycling, followed by ten 60-second high-intensity exercise bouts interspersed with 60-second recovery periods of low-intensity cycling. The intensity of HIIT was set at 75% of peak work rate (WR) for ASTH and 80% of peak WR for CON, determined during a preliminary exercise test. Sessions concluded with a 5-minute loadless cycling cooldown.

#### Pulmonary Function and Inflammation Measures-

Pulmonary function was assessed using peak expiratory flow (PEF), forced vital capacity (FVC), and the ratio of forced expiratory volume in one second to FVC (FEV1/FVC). The fractional concentration of exhaled nitric oxide (FeNO), indicating lung inflammation, was measured using a NIOX portable device. Measurements were taken before and after the completion of the HIIT protocol.

#### Exercise Tolerance Measures-

A progressive exercise test on a cycle ergometer was performed to determine peak oxygen uptake ( $\text{VO}_{2\text{peak}}$ ), carbon dioxide output ( $\text{VCO}_{2\text{peak}}$ ), ventilation (VE), and time to exhaustion (TTE). The test began with a 20 W/min increase until volitional exhaustion.

#### Statistical Analysis-

Data were analyzed using a two-way analysis of variance with repeated measures (ANOVA-RM) to examine the main effects of group (CON vs. ASTH) and time (Pre- vs. Post-HIIT) and their interaction. A Student Newman Kuels post hoc test determined specific differences where appropriate. Statistical significance was set at  $p < 0.05$ .

### Results

The study evaluated the effects of High Intensity Interval Training (HIIT) on pulmonary function, exercise tolerance, and the fractional concentration of exhaled nitric oxide (FeNO) in asthmatic (ASTH) and healthy control (CON) groups. Below are the summarized findings.

#### Demographic Information-

Both groups were composed of adult males, with no significant differences in age, height, or weight between the ASTH and CON groups at baseline.

#### Pulmonary Function Tests-

No significant changes were observed in pulmonary function (PEF, FVC, FEV1/FVC ratio) for either group post-HIIT, indicating that the exercise differences were more pronounced in the ASTH group.

#### Ventilation (VE) and Carbon Dioxide Output ( $\text{VCO}_2$ )-

Both VE and  $\text{VCO}_2$  showed significant increases post-HIIT in both groups, Suggesting improved exercise efficiency and ventilation capacity.

### Table 1: Demographic Variables of the Subjects

Group	Age (Years)	Height (cm)	Weight (kg)
Asthmatic	25.9 ± 5.1	174.4 ± 7.5	79.8 ± 17.1
Healthy	22.6 ± 3.4	175.8 ± 6.5	75.6 ± 12.3

**Table 2: Pulmonary Function Tests (Pre- and Post-HIIT)**

Measurement	Asthmatic Pre	Asthmatic Post	Healthy Pre	Healthy Post
PEF (L/min)	556 ± 25	561 ± 23	567 ± 29	571 ± 29
FVC (L)	4.167 ± 0.3	4.294 ± 0.3	5.086 ± 0.3	5.066 ± 0.4
FEV1 (L)	3.6 ± 0.3	3.8 ± 0.3	4.2 ± 0.2	4.2 ± 0.2
FEV1/FVC (%)	87 ± 3	89 ± 3	82 ± 0	83 ± 0

**Table 3: Exercise Tolerance and Ventilation (Pre- and Post-HIIT)**

Measurement	Asthmatic Pre	Asthmatic Post	Healthy Pre	Healthy Post
VO2 Max (L/min)	2.45 ± 0.1	2.67 ± 0.2	3.83 ± 0.1	3.78 ± 0.3
TTE (sec)	691 ± 40	781 ± 41	998 ± 23	1033 ± 36
PWR (watts)	175 ± 13	203 ± 14	290 ± 10	302 ± 13
VCO2 (L/min)	2.72 ± 0.2	3.27 ± 0.2	4.58 ± 0.2	4.49 ± 0.3
VE (L/min)	77.77 ± 7.9	95.81 ± 6.6	134.69 ± 8.7	137.40 ± 15.3

**Table 4: Fractional Exhaled Nitric Oxide (FeNO) Levels (Pre- and Post-HIIT)**

Group	Pre-HIIT (ppb)	Post-HIIT (ppb)
Asthmatic	28 ± 2	28 ± 2
Healthy	18 ± 1	16 ± 3

### Observations and Significant Findings:

- **Pulmonary Function-** No significant changes were observed in the pulmonary function tests (PEF, FVC, FEV1, FEV1/FVC ratio) for both groups post-HIIT, indicating the exercise protocol did not adversely affect these measures.
- **Exercise Tolerance:** Significant improvements were noted in TTE and PWR for the asthmatic group post-HIIT, demonstrating enhanced exercise tolerance. The healthy group also showed improvements, but the changes were more pronounced in the asthmatic group.
- **Ventilation and VCO2:** Both VE and VCO2 exhibited significant increases post-HIIT in both groups, suggesting improved exercise efficiency and ventilation capacity.
- **FeNO Levels:** FeNO levels remained stable in both groups, with no significant increase post-HIIT, suggesting that the exercise protocol did not exacerbate airway inflammation in asthmatic participants.

These results suggest that HIIT is a safe and effective exercise modality for improving exercise tolerance and ventilation in asthmatic individuals without adversely affecting pulmonary function or increasing airway inflammation.

### **Discussion:**

The findings of this study provide compelling evidence that High Intensity Interval Training (HIIT) can significantly enhance exercise tolerance and ventilation in individuals with asthma without adversely affecting pulmonary function or exacerbating airway inflammation. These outcomes align with previous research suggesting that physical activity, particularly of moderate to high intensity, can offer substantial health benefits for asthmatic individuals, including improvements in cardiorespiratory fitness and symptom control (1,2).

The lack of significant changes in pulmonary function tests (PFTs) such as PEF, FVC, and FEV1/FVC ratio post-HIIT, observed in both asthmatic and healthy participants, corroborates existing literature indicating that HIIT does not compromise lung function in asthmatics (3). This is particularly relevant given the chronic nature of asthma and the potential concern that high-intensity exercise could trigger bronchoconstriction or worsen symptoms. However, the stability of these measures post-intervention suggests that HIIT, when appropriately tailored, is a safe exercise modality for this population.

The significant improvements in time to exhaustion (TTE) and peak work rate (PWR) exclusively in the asthmatic group suggest a greater capacity for adaptation in exercise tolerance among those with asthma compared to healthy individuals. This finding is notable as it indicates that asthmatic individuals, who often experience exercise-induced limitations, can achieve substantial gains in exercise performance through HIIT. These results are in line with studies by Emtner et al., who also reported improvements in physical fitness and pulmonary function following a regimen of aquatic HIIT in adults with mild to moderate asthma (4).

Furthermore, the observation of significant increases in minute ventilation (VE) and carbon dioxide output (VCO<sub>2</sub>) post-HIIT supports the hypothesis that HIIT enhances the efficiency of the ventilatory response to exercise. This enhancement in ventilatory efficiency is crucial for asthmatic individuals, as

it could potentially improve their ability to engage in daily activities and exercise with reduced dyspnea. The improvements in VE and VCO<sub>2</sub> are consistent with findings from Ramos et al., which indicated that HIIT improves ventilatory efficiency and exercise capacity in patients with chronic obstructive pulmonary disease, a group that shares similar exercise-induced challenges with asthmatics (5).

## Conclusion

The stability of fractional exhaled nitric oxide (FeNO) levels before and after the HIIT intervention further supports the argument that HIIT does not exacerbate airway inflammation in asthmatics. This is an important consideration, as increased FeNO levels are indicative of eosinophilic airway inflammation, which is a characteristic feature of asthma exacerbations (6). The maintenance of FeNO levels suggests that the inflammatory status of the airway does not worsen with HIIT, making it a potentially viable exercise option for asthma management.

## REFERENCES

1. Mendes FAR, Gonçalves RC, Nunes MPT, Saraiva-Romanholo BM, Cukier A, Stelmach R, et al. Effects of aerobic training on airway inflammation in asthmatic patients. *Med Sci Sports Exerc*. 2011;43(2):197-203.
2. Carson KV, Chandratilleke MG, Picot J, Brinn MP, Esterman AJ, Smith BJ. Physical training for asthma. *Cochrane Database Syst Rev*. 2013;(9):CD001116.
3. Turner S, Eastwood P, Cook A, Jenkins S. Improvements in symptoms and quality of life following exercise training in older adults with moderate/severe persistent asthma. *Respirology*. 2011;16(1):76-84.
4. Emtner M, Finne M, Stålenheim G. High-intensity physical training in adults with asthma. A 10-week rehabilitation program. *Chest*. 1998;113(4):1103-10.
5. Ramos EMC, Vanderlei LCM, Ito JT, Rodrigues FM, Gagliardi ART, Bertolini GRY, et al. High-intensity interval training in patients with chronic obstructive pulmonary disease: a systematic review. *COPD*. 2019;16(1):43-57
6. Dweik RA, Boggs PB, Erzurum SC, Irvin CG, Leigh MW, Lundberg JO, et al. An official ATS clinical practice guideline: interpretation of exhaled nitric oxide levels (FENO) for clinical applications. *Am J Respir Crit Care Med*. 2011;184(5):602-15.