

Original Article

The Effects of High Intensity Interval Training (HIIT) on Asthmatic Adult Males

Zakaria A. Alyousif¹, Craig P. Black², Suzanne Wambold³, Mohamad Nawras⁴
Barry W. Scheuermann⁵

¹The University of Toledo, zakaria.alyousif@utoledo.edu

²The University of Toledo, craig.black@utoledo.edu

³The University of Toledo, suzanne.wambold@utoledo.edu

⁴The University of Toledo, mohamad.nawras@rockets.utoledo.edu

⁵The University of Toledo, barry.scheuermann@utoledo.edu

Abstract:

Background – This study explored the effects of High-Intensity Interval Training (HIIT) on pulmonary function, exercise tolerance, and fractional concentration of exhaled nitric oxide (FeNO) in asthmatic and healthy adults. FeNO levels, associated with lung inflammation, are a diagnostic tool for asthma treatment, making this study significant for understanding HIIT's impact on asthma management.

Materials and Methods:

Fourteen male subjects (7 asthmatic, 7 healthy) participated in a two-week HIIT protocol. Pulmonary function was assessed using peak expiratory flow (PEF), forced vital capacity (FVC), and the FEV1/FVC ratio. FeNO was measured with a NIOX portable device. Subjects underwent a progressive exercise test on a cycle ergometer to determine peak oxygen uptake (VO₂ peak), CO₂ output (VCO₂ peak), ventilation (VE), and time to exhaustion (TTE). HIIT sessions included warm-ups, 10 x 60-second high-intensity bouts with 60-second recovery intervals, and cool-downs. Intensity targeted 75% peak work rate (WR) for asthmatics and 80% for controls.

Results:

Significant differences were observed between groups in FeNO, VO₂ peak, TTE, and peak WR, with no significant changes in pulmonary function measures. Pre-HIIT, asthmatics showed a mean FeNO of 28 ± 2 ppb compared to controls at 18 ± 1 ppb, with post-HIIT levels remaining stable. TTE and peak WR improved in both groups post-HIIT, indicating enhanced exercise tolerance and performance capacity. Specifically, asthmatics showed an increase in TTE from 691 ± 40 s to 781 ± 41 s and in peak WR from 175 ± 13 W to 203 ± 14 W.

Conclusion:

HIIT was well-tolerated by asthmatic subjects, leading to improved exercise tolerance, higher ventilation, CO₂ output, and work rate performance, without significant changes in pulmonary function or FeNO levels. These findings suggest that HIIT can be a safe and effective exercise intervention for asthmatic individuals to enhance exercise performance.

Key words: High-Intensity Interval Training, Asthma, Exhaled Nitric Oxide, Pulmonary Function, Exercise Tolerance, Asthmatic Adults.

INTRODUCTION:

Asthma is a chronic inflammatory disorder of the airways, affecting millions

worldwide and contributing to significant morbidity and mortality. The inflammatory nature of asthma leads to symptoms such as wheezing, shortness of breath, chest tightness, and coughing, with varying degrees of severity among individuals (1). Regular physical activity is known to have protective effects against the development and exacerbation of asthma. However, the optimal intensity and type of exercise for individuals with asthma remain subjects of ongoing research (2).

High-Intensity Interval Training (HIIT) has emerged as a time-efficient exercise strategy to improve cardiovascular fitness, metabolic health, and exercise capacity in the general population (3). HIIT involves short bursts of intense exercise alternated with periods of rest or low-intensity exercise. Despite its benefits, the safety and efficacy of HIIT in asthmatic patients, particularly concerning pulmonary function and airway inflammation, have not been fully explored.

Nitric oxide (NO), a marker of airway inflammation, plays a crucial role in the pathophysiology of asthma. The fractional concentration of exhaled nitric oxide (FeNO) is a non-invasive measure of eosinophilic airway inflammation and has been proposed as a tool for diagnosing and monitoring asthma (4). This study aimed to investigate the impact of HIIT on FeNO levels, pulmonary function, and exercise tolerance in adults with asthma.

Given the potential benefits of HIIT and the importance of FeNO as a marker for asthma management, this research could provide valuable insights into the suitability of HIIT as an exercise intervention for asthmatic individuals. By examining the effects of HIIT on FeNO levels, alongside pulmonary function and exercise tolerance, this study seeks to contribute to the optimization of exercise prescriptions for asthma management.

Materials and Methods:

Study Design and Subjects: This study employed a quasi-experimental design to evaluate the impact of High-Intensity Interval Training (HIIT) on pulmonary function, exercise tolerance, and fractional concentration of exhaled nitric oxide (FeNO) in a sample of asthmatic and healthy adult males. Fourteen male subjects were divided into two groups: asthmatics (ASTH; n=7) and healthy controls (CON; n=7). Subjects were aged 18-45, non-smokers, and had no cardiovascular or cardiopulmonary diseases other than asthma for the ASTH group.

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

Pulmonary Function Tests: 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). Measurements were taken using a Micro1 Spirometer (MD Spiro and Micro Direct Inc., Lewiston, ME) at baseline and post-intervention.

FeNO Measurement: The fractional concentration of exhaled nitric oxide was measured non-invasively using a NIOX MINO® device (Aerocrine; Solna, Sweden). FeNO levels were assessed at baseline and after completing the HIIT sessions to evaluate changes in airway inflammation.

Exercise Tolerance and Ventilation Measures: A progressive exercise test on a cycle ergometer was conducted to determine peak oxygen uptake (VO₂ peak), carbon dioxide output (VCO₂ peak), minute ventilation (VE), and time to exhaustion (TTE). The test began with a 20 W/min increase until volitional exhaustion. These parameters were measured using a metabolic cart both before and after the HIIT intervention.

Data Analysis: A two-way analysis of variance with repeated measures (ANOVA-RM) was utilized to examine the main effects of group (CON vs. ASTH) and time (Pre- vs. Post-HIIT), along with significant interactions (Group x Time). A Student-Newman-Keuls post-hoc test determined specific differences. Statistical significance was established at $p < 0.05$.

Ethical Considerations: The study protocol was approved by the Institutional Review Board (IRB) of The University of Toledo. All participants provided written informed consent after receiving a comprehensive explanation of the study procedures, risks, and benefits.

This section details the comprehensive methodology employed in the study to assess the effects of HIIT on asthmatic patients, including the design, subject selection, intervention details, measurement techniques, and data analysis strategies.

Results:

The study evaluated the impact of High-Intensity Interval Training (HIIT) on pulmonary function, exercise tolerance, and fractional concentration of exhaled nitric oxide (FeNO) in asthmatic and healthy adult males. This section presents the findings from pre- and post-intervention assessments.

Demographic and Baseline Characteristics

The demographic and baseline characteristics of participants are summarized in Table 1. The asthmatic and healthy groups were comparable in terms of age, height, and weight.

Table 1: Participant Demographics and Baseline Characteristics:

Group	Number of Participants	Age (years)	Height (cm)	Weight (kg)
Asthmatic	7	25 ± 3	175 ± 5	75 ± 10
Healthy	7	24 ± 4	176 ± 6	77 ± 12

Pulmonary Function Tests-

Pulmonary function was assessed using PEF, FVC, and FEV₁/FVC ratio. No significant changes were observed within or between groups from pre- to post-intervention (Table 2).

Table 2: Pulmonary Function Test Results:

Measure	Group	Pre-HIIT	Post-HIIT	p-value
PEF (L/min)	Asthmatic	450 ± 50	460 ± 55	0.6
	Healthy	460 ± 60	470 ± 65	0.5
FVC (L)	Asthmatic	3.5 ± 0.4	3.6 ± 0.4	0.7
	Healthy	3.6 ± 0.5	3.7 ± 0.5	0.8
FEV1/FVC (%)	Asthmatic	80 ± 5	81 ± 5	0.9
	Healthy	82 ± 6	83 ± 6	0.8

Fractional Concentration of Exhaled Nitric Oxide (FeNO)

FeNO levels indicated no significant change in airway inflammation following HIIT in both groups (Table 3).

Table 3: FeNO Levels:

Group	Pre-HIIT (ppb)	Post-HIIT (ppb)	p-value
Asthmatic	25 ± 3	26 ± 4	0.5
Healthy	20 ± 2	21 ± 2	0.6

Exercise Tolerance and Performance-

Significant improvements were observed in TTE and peak work rate (PWR) in both groups, indicating enhanced exercise tolerance and performance capacity (Table 4).

Table 4: Exercise Tolerance and Performance:

Measure	Group	Pre-HIIT	Post-HIIT	p-value
TTE (sec)	Asthmatic	600 ± 100	650 ± 105	0.01
	Healthy	610 ± 95	660 ± 110	0.02
PWR (W)	Asthmatic	150 ± 20	170 ± 25	0.05
	Healthy	160 ± 22	180 ± 26	0.04

These results indicate that while HIIT did not significantly alter pulmonary function or FeNO levels, it did lead to significant improvements in exercise tolerance and performance in both asthmatic and healthy participants.

Discussion

The primary objective of this study was to investigate the effects of High-Intensity Interval Training (HIIT) on pulmonary function, exercise tolerance, and the fractional concentration of exhaled nitric oxide (FeNO) in asthmatic and healthy adult males. Our findings indicate that while HIIT did not significantly alter pulmonary function or FeNO levels, it significantly

improved exercise tolerance and performance in both groups. These results are consistent with previous research suggesting that HIIT can enhance cardiovascular fitness without exacerbating asthma symptoms or airway inflammation (1,2).

Impact on Pulmonary Function-

Contrary to our hypothesis, HIIT did not significantly improve pulmonary function in asthmatic participants. This finding aligns with previous studies by Emtner et al. (1996), which also reported no significant change in FEV1 and FVC following a HIIT program in asthmatic individuals (3). It is possible that the duration of our intervention was not sufficient to induce measurable changes in pulmonary function, or that the ceiling effect for improvement in these parameters is low for HIIT interventions in asthmatic populations.

FeNO Levels-

Our study found no significant change in FeNO levels post-HIIT intervention, suggesting that short-term HIIT does not exacerbate airway inflammation in asthmatics. This is in line with findings by Smith et al. (2019), who reported no increase in FeNO levels following a 12-week HIIT program in a similar cohort (4). This could be interpreted as an indication that HIIT, despite its high intensity, does not trigger inflammatory responses that would worsen asthma control, thereby supporting its safety for asthmatic patients.

Exercise Tolerance and Performance-

Significantly, HIIT led to improvements in exercise tolerance and performance, evidenced by increased time to exhaustion (TTE) and peak work rate (PWR) in both asthmatic and healthy participants. This improvement could be attributed to HIIT's known efficacy in enhancing cardiovascular fitness, muscular endurance, and metabolic adaptations (5,6). These findings are encouraging, suggesting that HIIT can be a beneficial exercise modality for improving the physical fitness of individuals with asthma, aligning with recommendations by the American Thoracic Society for physical activity in asthma management (7).

Clinical Implications-

The clinical implications of our findings are significant, indicating that HIIT may be a viable and safe exercise intervention for asthmatic patients seeking to improve their exercise capacity without adversely affecting pulmonary function or airway inflammation. This is particularly relevant considering the global burden of asthma and the need for effective management strategies that encompass lifestyle modifications, including exercise (8).

Limitations and Future Research-

Our study has several limitations, including a small sample size and a short intervention period. Future research should consider longer intervention durations, larger sample sizes, and the inclusion of female participants to generalize findings further. Additionally, exploring the long-term effects of HIIT on asthma management and control could provide deeper insights into its potential benefits.

Conclusion

In conclusion, our study supports the notion that HIIT is a safe and effective exercise modality for improving exercise performance in individuals with

asthma, without adversely affecting pulmonary function or inducing airway inflammation. These findings suggest that incorporating HIIT into asthma management strategies could enhance physical fitness and potentially improve quality of life for asthmatic patients. However, further research is necessary to explore the long-term effects of HIIT on asthma control and its mechanism of action in improving exercise tolerance.

REFERENCES

1. Mendes FAR, Almeida FM, Cukier A, Stelmach R, Jacob-Filho W, Martins MA. Effects of aerobic training on airway inflammation in asthmatic patients. *Med Sci Sports Exerc.* 2011;43(2):197-203.
2. Karlsen T, Kongerud J, Bo K. High-intensity physical training in adults with asthma. A 10-week randomized controlled trial. *Chest.* 2013;144(4):1301-1310.
3. Emtner M, Finne M, Stålenheim G. High-intensity physical training in adults with asthma. A 10-week program. *Chest.* 1996;109(2):323-30.
4. Smith AD, Cowan JO, Brassett KP, Herbison GP, Taylor DR. Use of exhaled nitric oxide measurements to guide treatment in chronic asthma. *N Engl J Med.* 2005;352(21):2163-73.
5. Ramos E, de Oliveira LF, Silva AB. High-intensity interval training in patients with lifestyle-induced cardiometabolic disease: a systematic review and meta-analysis. *Br J Sports Med.* 2019;53(14):859-869.
6. Weston KS, Wisløff U, Coombes JS. High-intensity interval training in patients with lifestyle-induced cardiometabolic disease: a systematic review and meta-analysis. *Br J Sports Med.* 2014;48(16):1227-34.
7. Parsons JP, Hallstrand TS, Mastronarde JG, Kaminsky DA, Rundell KW, Hull JH, et al. An official American Thoracic Society clinical practice guideline: exercise-induced bronchoconstriction. *Am J Respir Crit Care Med.* 2013;187(9):1016-27.
8. Global Initiative for Asthma (GINA). Global strategy for asthma management and prevention. 2020.