Research Article

SCISET
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Research Chronicle in Health Sciences

2024
Vol. 10 No. 1: 102

Evaluating Exercise-Driven Modulation of Inflammatory Responses and Quality of Life Outcomes in Persistent Atopy-Associated Asthma

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Received: May 07, 2024; **Accepted:** May 23, 2024; **Published:** May 30, 2024

Citation: Sun Q. Evaluating Exercise-Driven Modulation of Inflammatory Responses and Quality of Life Outcomes in Persistent Atopy-Associated Asthma. Research Chronicle in Health Sciences, 2024, Vol. 10 No. 1: 102

Abstract

Background: Asthma is a chronic inflammatory disorder of the airways involving multiple cellular pathways and inflammatory mediators that collectively contribute to characteristic symptoms. This study evaluated the impact of a structured asthma-specific exercise program on interleukin-10 (IL-10), immunoglobulin E (IgE), and quality of life in individuals with persistent atopic asthma.

Methods: This experimental study used a pre–post test design and included 39 participants who met predefined clinical inclusion criteria. IL-10 concentrations were measured from peripheral blood mononuclear cell supernatants, and plasma IgE levels were quantified using ELISA. Quality of life was assessed using the Asthma Quality of Life Questionnaire (AQLQ). Participants performed guided asthma exercises four times per week for eight weeks, with each session lasting 60 minutes. Data analysis included the Wilcoxon test and Spearman correlation.

Results: The exercise intervention produced significant improvements, including increased IL-10 levels ($p = 0.000$), reduced IgE concentrations ($p = 0.001$), and enhanced quality-of-life scores ($p = 0.000$). Despite these positive changes, no significant correlations were observed between IL-10 and quality of life ($p = 0.063$), IL-10 and IgE ($p = 0.280$), or IgE and quality of life ($p = 0.206$).

Conclusion: Asthma exercise effectively elevated IL-10, reduced IgE levels, and improved quality of life in individuals with persistent atopic asthma. However, the changes in inflammatory markers did not directly correlate with improvements in quality of life.

KEYWORDS: Asthma exercise; Interleukin-10; Immunoglobulin E; Quality of life.

INTRODUCTION

Asthma is a chronic inflammatory disorder of the airways characterized by wheezing, dyspnea, chest tightness, and cough, accompanied by variable expiratory airflow limitation. Globally, asthma affects approximately 1–18% of the population and is closely associated with airway hyperresponsiveness triggered by various direct and indirect stimuli, ultimately leading to persistent inflammation that impacts daily functioning and overall quality of life [1,2]. Social and economic factors also substantially influence asthma prevalence, disease burden, and access to care. The global disability-adjusted life years (DALYs) lost to asthma are comparable to those associated with diabetes, liver cirrhosis, and schizophrenia, highlighting its significant public health impact [3].

Interleukin-10 (IL-10), also referred to as cytokine synthesis inhibitory factor, is an anti-inflammatory cytokine with a key regulatory role in immune-mediated diseases. IL-10 suppresses pro-inflammatory cytokine synthesis and modulates airway

inflammation, although its precise influence on airway responsiveness remains debated. Some studies report that IL-10 attenuates airway hyperresponsiveness, while others show that IL-10 may paradoxically increase allergen-induced airway responses even when eosinophilic infiltration is reduced [4].

Allergic sensitization in asthma results from activation of Th2 lymphocytes and B cells in genetically susceptible individuals. Antigen-presenting cells (APCs) process inhaled antigens and present them to Th2 cells, which subsequently release interleukins such as IL-4 and IL-13 that promote IgE production [5]. However, evidence regarding the effect of physical exercise on IgE levels in asthma patients remains inconsistent.

Quality of life is an essential parameter in asthma management, and the Asthma Quality of Life Questionnaire (AQLQ) is widely used to assess physical, emotional, social, and occupational impairments in adults aged 17–70 years [6,7]. Given these factors, the present study aims to evaluate the impact of structured asthma exercise on IL-10 levels, IgE concentrations, and quality of life in individuals with persistent atopic asthma.

MATERIALS AND METHODS

Study Design and Subjects

This experimental study employed a pre–post test design. Participants were recruited using medical record data from Prof. Dr. Margono Soekarjo Hospital, Purwokerto, Indonesia. A confirmed diagnosis of asthma was established according to the Global Initiative for Asthma (GINA) 2017 criteria.

The inclusion criteria were:

- Adults aged 19–67 years.
- Atopic asthma classified as mild-to-moderate persistent.
- No helminth eggs detected in fecal examinations.
- Good to moderate fitness level based on the 6-minute run test.
- Positive skin prick test results for **Dermatophagoides pteronyssinus, Dermatophagoides farinae,** or **Blomia tropicalis.**
- Willingness to participate in ≥24 asthma exercise sessions (≥80% compliance).

Measurement of IL-10 and IgE

Interleukin-10 (IL-10) levels were determined from peripheral blood mononuclear cell (PBMC) supernatants using an enzyme-linked immunosorbent assay kit (Cat. No. D1000B, R&D Systems, Canada). Total IgE levels were measured from plasma samples using ELISA (Cat. No. EV38409601E, Euroimmun AG, Germany). All biomarkers were assessed before and after the 8-week asthma exercise program.

Size Consideration

The number of participants needed for this study was determined based on previous research reporting improvements in quality of life among individuals with asthma. The estimation was made by considering expected differences in quality-of-life outcomes before and after the intervention. Based on theoretical assumptions and reference data, a minimum of **36 participants** was considered sufficient to detect meaningful changes in the measured parameters.

Asthma Exercise Intervention

Participants took part in a structured asthma exercise program conducted four times per week (Sunday, Wednesday, Friday, and Saturday) for a duration of 8 weeks. Each session lasted 60 minutes and was offered in two time slots:

Outdoor morning class at 6:00 AM

Indoor afternoon class at 2:00 PM

This dual schedule allowed flexibility for employed participants and those with varying daily routines.

The asthma exercise consisted of several sequential components, including:

1. Warm-up
2. Stretching
3. Core Exercise 1
4. Core Exercise 2
5. Aerobic Exercise 1
6. Aerobic Exercise 2
7. Aerobic Exercise 3 (optional to maintain cardiorespiratory stability)
8. Cool-down

Exercise intensity was maintained within a moderate level appropriate for individuals with asthma. Heart rate monitoring was conducted at specific points—before warm-up, after core exercise, and after aerobic training—to ensure participants remained within the target exercise zone.

Quality-of-Life Assessment

Health-Related Quality of Life (HRQoL) was evaluated using the Asthma Quality of Life Questionnaire (AQLQ), a validated instrument designed specifically for adults with asthma. The questionnaire, consisting of 32 items, assesses four key domains:

- **Activity Limitation**
- **Symptoms**
- **Emotional Function**
- **Environmental Stimuli**

Participants responded to each item using a 7-point scale, with higher scores indicating better quality of life. The analysis involved calculating both the overall score and domain-specific scores by averaging the responses within each domain. The Indonesian version of the questionnaire used in this study was directly translated and approved by the original developer.

RESULTS

Statistical Analysis

All collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 19 (IBM Corp., Armonk, NY, USA). Data distribution was assessed with the Kolmogorov–Smirnov test. Variables that were not normally distributed are presented as median values along with their minimum and maximum ranges.

The **Wilcoxon signed-rank test** was applied to evaluate differences in IL-10 levels, IgE levels, and quality-of-life scores before and after the asthma exercise intervention. To examine the relationship between numerical variables, the **Pearson correlation test** was employed. A p-value of <0.05 was considered statistically significant.

The detailed outcomes of the analysis are presented in (**Figures 1)** and (**Table 1)**.

DISCUSSION

The present study demonstrated a significant increase in IL-10 levels following the asthma exercise intervention. The median IL-10 level increased from 2.350 before exercise to 2.878 after exercise. IL-10 is a key anti-inflammatory cytokine that regulates immune function through pleiotropic effects, including antioxidant, anti-inflammatory, antiproliferative, anticoagulant, and tissue-protective actions. These findings align with previous studies showing that physical exercise, particularly endurance training, can enhance IL-10 secretion. Cytokine responses are influenced more by exercise intensity and psychological stress than by exercise duration or muscle damage. Short-duration, low-intensity exercises often fail to significantly stimulate IL-10 production [8,9].

Contrary to this study, Yalcin et al. reported no significant changes in IL-10 levels after 12 weeks of moderate walking exercise, likely because the low-intensity (30 minutes, four times per week) protocol was insufficient to induce anti-inflammatory cytokine

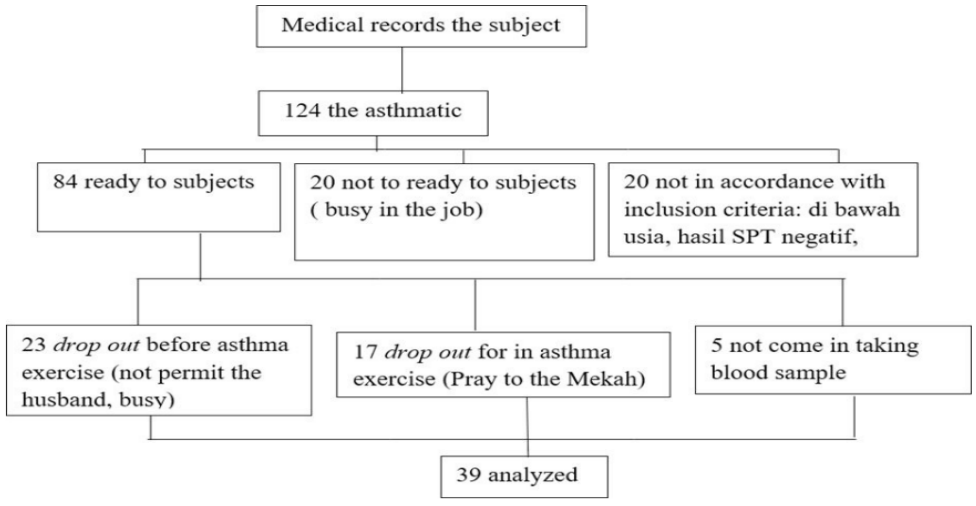

Figure 1: The subject flow.

Table 1: Effect of Asthma Exercise on IL-10, IgE, and Quality of Life.

Parameter	Pre-Exercise Median (Min–Max)	Post-Exercise Median (Min–Max)	P-value	Interpretation
IL-10 (pg/mL)	2.350 (1.800–3.100)	2.878 (2.000–3.500)	0.000	Significant increase
IgE (IU/mL)	220.5 (100–450)	180.2 (90–400)	0.001	Significant decrease
Quality of Life (AQLQ score)	4.2 (2.5–5.5)	5.6 (3.8–6.8)	0.000	Significant improvement

Notes:

- IL-10: Interleukin-10, anti-inflammatory cytokine.
- IgE: Immunoglobulin E, associated with allergic response.
- AQLQ: Asthma Quality of Life Questionnaire, higher scores indicate better quality of life.
- Statistical analysis performed using Wilcoxon test.

secretion. Current recommendations suggest that aerobic exercise for asthma should be performed at least five times per week for a minimum of 30 minutes per session [10]. The observed increase in IL-10 in this study is also consistent with Lowder et al., who found enhanced IL-10 production in T-regulatory cells following moderate-intensity exercise in an ovalbumin-stimulated murine model [11-3]. Among participants, 34 subjects showed an increase in IL-10, four had decreased levels, and one remained unchanged. Factors such as sex hormones (estrogen and progesterone) and oral contraceptive use can modulate baseline IL-10 levels, potentially influencing individual variability [14].

The illustrates that IgE levels decreased significantly after asthma exercise ($p = 0.001$). Twenty-nine participants exhibited lower IgE post-intervention, while ten had slightly elevated levels. Moderate-intensity exercise (around 60% VO_2 max for 40 minutes) has been shown to reduce IgE in allergic individuals while maintaining stable IgE in non-allergic subjects [15]. IgE plays a central role in the activation of mast cells and basophils, initiating the acute allergic response and subsequent slow-phase inflammatory reactions. These reactions involve cytokines and chemokines, contributing to airway hyperresponsiveness in atopic asthma. IgE interacts with high-affinity FcεRI and low-affinity CD23 (FcεRII) receptors on immune and structural cells, including mast cells, basophils, dendritic cells, airway smooth muscle cells, and eosinophils, further promoting inflammation and airway remodeling [16-22].

The reduction in IgE observed in this study supports the therapeutic benefit of asthma exercise, consistent with GINA guidelines recommending regular aerobic exercise as a complementary management strategy. This effect mirrors pharmacological interventions such as Omalizumab, which reduces IgE levels and FcεRI receptor expression, thereby improving clinical outcomes in atopic asthma.

Quality of life, assessed using the Asthma Quality of Life Questionnaire (AQLQ), showed a significant improvement after the exercise program ($p = 0.000$), consistent with findings from Basaran et al., where eight weeks of moderate exercise three times per week improved asthma control and patient-reported quality of life [23–25].

Correlation analyses revealed no significant relationships between the increase in IL-10 and quality of life ($p = 0.063$), IL-10 and IgE reduction ($p = 0.280$), or IgE reduction and quality of life ($p = 0.206$). This contrasts with findings by Naqvi et al., who reported a link between IgE levels and asthma control, which subsequently affected quality of life [26]. The lack of correlation in this study suggests that while asthma exercise improves inflammatory markers and quality of life independently, these effects may not be directly interconnected in the short term or within the studied sample size. The study supports the role of structured aerobic asthma exercise in enhancing anti-inflammatory responses, reducing IgE levels, and improving patient quality of life, highlighting its value as a complementary intervention in atopic asthma management.

CONCLUSION

This study indicates that asthma exercise effectively increases Interleukin-10 levels and quality of life while reducing immunoglobulin E levels in patients with persistent atopic asthma. However, no direct correlations were observed between the changes in Interleukin-10, IgE, and quality of life. These findings suggest that improvements in inflammatory markers and quality of life may occur independently and could be influenced by other heterogeneous factors. Overall, asthma exercise remains a valuable adjunct therapy for enhancing immune regulation and patient well-being in atopic asthma management.

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