Asthma and aerobic exercise: A review of the empirical literature

Kimberly M. Avallone & Alison C. McLeish

Objective: The purpose of the present paper was to provide a comprehensive review of the empirical literature on the association between asthma and aerobic exercise among adults. Methods: A literature search was conducted utilizing electronic search engines (i.e., PsycINFO and PubMed) using the following keyword algorithms: asthma AND (exercise OR physical activity). Results: These searches resulted in approximately 5,665 citations. Only results that were directly relevant were included in the present review. Conclusions: Overall, empirical evidence suggests that (1) individuals with asthma are less likely to engage in physical activity than those without asthma; (2) individuals with asthma are not biased in their subjective reporting of symptoms during aerobic exercise; (3) physical inactivity among individuals with asthma is associated with negative health consequences and increased asthma-related difficulties; and (4) regular aerobic exercise improves asthma symptom management, lung function, and mental health.
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Keywords: asthma, aerobic exercise, physical activity, aerobic activity
Abstract

Objective: The purpose of the present paper was to provide a comprehensive review of the empirical literature on the association between asthma and aerobic exercise among adults.

Methods: A literature search was conducted utilizing electronic search engines (i.e., PsycINFO and PubMed) using the following keyword algorithms: asthma AND (exercise OR physical activity). Results: These searches resulted in approximately 5,665 citations. Only results that were directly relevant were included in the present review. Conclusions: Overall, empirical evidence suggests that (1) individuals with asthma are less likely to engage in physical activity than those without asthma; (2) individuals with asthma are not biased in their subjective reporting of symptoms during aerobic exercise; (3) physical inactivity among individuals with asthma is associated with negative health consequences and increased asthma-related difficulties; and (4) regular aerobic exercise improves asthma symptom management, lung function, and mental health.
Introduction

Despite the well-established benefits of exercise, approximately one-fourth of adults in the U.S. do not engage in any type of regular exercise, and almost half of those who do exercise fail to meet the federal physical activity guidelines for aerobic and muscle-strengthening exercise (i.e., 2.5 hours of moderate intensity aerobic activity and muscle-strengthening activities on two or more days per week) [1]. Individuals with asthma may be particularly at risk for failing to meet federal guidelines for physical activity, because exercise is often a trigger of asthma symptoms and exacerbations [2-4]. Indeed, while regular exercise has been found to result in improvements in lung functioning and asthma symptom management [3, 4], approximately 40-90% of individuals with asthma experience asthma symptoms as a result of exercise [5-7]. Although effective pharmacologic and nonpharmacologic approaches for managing symptoms related to asthma during exercise exist, individuals with asthma may avoid or limit their physical activity in order to prevent asthma exacerbations, resulting in significant negative health consequences [8].

While there is a large body of research examining associations between asthma and aerobic exercise among adults, no comprehensive, critical review of this literature exists. The purpose of the present paper, therefore, is to review the empirical literature on the association between asthma and aerobic exercise. In the first section of the paper, we define our search selection strategy. In the second section, we examine exercise habits among individuals with asthma. Third, we document symptom perception and physiological responses to exercise among individuals with asthma. Fourth, we review all available empirical information pertaining to aerobic exercise as an intervention or treatment for asthma. The final section of the paper
ASTHMA AND AEROBIC EXERCISE

highlights major gaps in empirical knowledge and delineates future directions for this area of research.

Method

Search Strategy and Study Selection Criteria

We conducted literature searches utilizing electronic search engines (i.e., PsycINFO and PubMed) to examine databases using the following key word combinations: Asthma AND (exercise OR physical activity). These searches yielded 5,665 citations. The majority of these were not relevant to the present review and were excluded because they (a) focused on only asthma or exercise; (b) examined exercise-induced asthma or exercise-induced bronchoconstriction; (c) did not involve aerobic exercise (e.g., studies examining deep breathing, yoga); (d) did not use a primarily adult sample; or (e) were not empirical articles. Please see Figure 1 for a detailed flow chart of study retrieval and selection. Thus, we focused on the remaining 23 articles that were directly applicable to the present review.

Results

Asthma and Exercise Habits

In an attempt to better understand the impact of aerobic exercise, one of the major lines of asthma research has focused on exercise habits among individuals with asthma (see Table 1 for a summary of these studies). Overall, the literature examining associations between asthma and physical activity suggests that individuals with a current or lifetime asthma diagnosis, compared to those without, engage in less physical activity [9, 10]. Moreover, when they do engage in exercise, individuals with asthma choose lower intensity activities (e.g., walking, gardening) over high intensity activities (e.g., running, competitive sports), potentially due to inaccurate beliefs about frequency, intensity, and types of exercise appropriate for individuals
with asthma [9, 11]. Studies suggest that this physical inactivity among individuals with asthma results in negative health consequences, such as poorer respiratory functioning (i.e., lower FEV$_1$ and PEF), greater health care utilization (e.g., increased physician office visits, ED visits, overnight hospital stays), decreased physical and mental health, and decreased quality of life [11-14]. There is also evidence that physical inactivity increases the risk of having a diagnosis of asthma and greater asthma severity [13]. In contrast, one study found that active (i.e., > 3.0 kcal/kg of body weight per day) individuals reported greater perceived overall health and mental health, greater satisfaction with life, fewer chronic medical conditions, and fewer activity limitations than individuals who were moderately active (i.e., 1.5 – 3.0 kcal/kg of body weight per day) or inactive (i.e., < 1.5 kcal/kg of body weight per day) [15]. The only study, to date, examining attitudes and barriers to physical activity among adult asthma patients indicates that despite believing in the benefits of physical activity, the majority of asthma patients avoided activities that were considered more intense (e.g., climbing stairs, competitive sports) and believed having a chronic medical condition was a barrier to engaging in physical activity [16]. Further, those with more severe asthma were more likely to believe that individuals with asthma should avoid physical activity altogether.

**Asthma and Exercise-Related Symptom Perception and Physiological Responding**

In addition to examining exercise habits, a number of studies have examined symptom perception and physiological responding during aerobic exercise among individuals with asthma (see Table 2 for a summary of these studies). While limited, the literature examining symptom perception during aerobic exercise suggests that individuals with asthma may not be biased in their symptom perception. Two of the three studies in this area found similar patterns of associations between subjective and objective ratings of physical symptoms while at rest and
exercising in those with and without asthma [17-18]; however, one study found that individuals with asthma or another chronic medical condition reported greater subjective symptoms of breathlessness during stress compared to those without asthma or another chronic medical condition [19]. The authors suggest that the presence of any physical illness, rather than asthma specifically, may make an individual more sensitive to bodily changes.

Research has also focused on examining the impact of physical activity on physiological outcomes (e.g., asthma exacerbations, lung function, heart rate variability) among individuals with asthma. Though also limited in number, studies in this area have consistently found that physical activity results in improved functioning across a number of physiological domains. Specifically, individuals with asthma who engage in regular physical activity have been found to report decreased asthma exacerbations and improved PEF and FEV\textsubscript{1} [3, 4]. There is also some evidence that physical activity may improve improved heart rate variability (HRV). Indeed, results of a study comparing adults with a physician diagnosis of mild to moderate asthma to age- and gender-matched controls suggest that although individuals with asthma have poorer HRV compared to their non-asthmatic peers, moderate to vigorous physical activity resulted in HRV levels similar to those without asthma who also engaged in moderate to vigorous physical activity [20].

**Aerobic Exercise as an Intervention for Asthma**

Given the benefits of physical activity for individuals with asthma, a number of studies have evaluated the utility of aerobic exercise as a treatment for asthma (see Table 3 for a summary of these studies). The majority of research in this area indicates that aerobic exercise results in a number of physiological and psychological improvements, including improved lung function (e.g., PEF, FEV\textsubscript{1}, FEF\textsubscript{25}), decreased airway inflammation (i.e., decreased total and
eosinophil counts in induced sputum), fewer asthma exacerbations, increased asthma control, fewer ED visits, and decreased anxiety and depression [21-27]. These effects do not appear to be limited to specific types of aerobic exercise as these benefits were found for various forms (e.g., combined strength training and aerobic exercise, indoor circuit training, swimming, treadmill; supervised versus unsupervised), intensities (e.g., exercise completed at 60-70% VO$_2$max; inactive, moderately active, active), and frequency (ranging from 6 weeks to 3 months) of aerobic exercise. It should be noted, however, that two studies did not find significant improvements in lung function [28, 29]. Indeed, one study only found aerobic exercise-related improvements in subjective (i.e., improved perceived asthma control and decreased self-reported frequency and severity of symptoms), but not objective (i.e., spirometry), measures of asthma symptoms and lung function [28]. This discrepancy may be due to the fact that the aerobic exercise intervention used in this study was the only self-guided intervention. Thus, aerobic exercise interventions may need to be more structured and led by a health professional in order to be maximally effective. The other study found that while a 6-week supervised aerobic exercise program resulted in significant improvements in asthma-related quality of life, no significant improvements in spirometry levels were found post-intervention [29].

**Discussion**

The present review evaluated existing empirical work focused on aerobic exercise and asthma. Overall, empirical evidence suggests that (1) individuals with asthma are less likely to engage in physical activity than those without asthma and are more likely to engage in lower intensity aerobic exercises when they do exercise; (2) individuals with asthma are not biased in their subjective reporting of symptoms during aerobic exercise; (3) physical inactivity among individuals with asthma is associated with general negative health consequences as well as
increased asthma-related difficulties; and (4) physical activity is associated with improvements in lung function (e.g., PEF, FEV₁, FEF₂₅), asthma symptom management (e.g., fewer asthma exacerbations, increased asthma control), and mental health (e.g., anxiety, depression).

A major strength of the existing literature on asthma and aerobic exercise lies in the diversity of samples and methodologies used. Studies in this area have used clinical, non-clinical, and epidemiologically defined samples as well as objective and subjective assessments of both asthma and aerobic exercise and laboratory-based as well as intervention research. Furthermore, researchers have examined various types and severity of asthma presentation as well as types of physical activity. The current review does, however, suggest a number of limitations and directions for future research.

First, there is a need to expand on the primarily cross-sectional nature of the current body of literature by conducting longitudinal studies that examine associations between asthma and aerobic exercise over time. Such studies would not only provide important information about how physical activity impacts asthma over time, but also information regarding the temporal pattern of these associations. A second limitation is that the majority of studies included in this review did not objectively verify asthma diagnosis. Objective verification of asthma diagnosis rather than relying on self-report or a previous diagnosis by a physician would increase confidence that the individual did indeed meet criteria for asthma. It would also be helpful for studies to specify how asthma was diagnosed by physicians when patients are recruited from clinics and hospitals so that diagnostic methods can be compared across studies. Third, few studies have examined the mechanisms (i.e., barriers and motivators) that influence physical activity level among individuals with asthma. Understanding these mechanisms would enable researchers to develop targeted intervention programs to address these barriers and increase
overall motivation to exercise among this population. Fourth, additional research is needed in order to better understand the physiological responses during aerobic exercise among individuals with asthma. Although the majority of studies that have been conducted in this area suggest that aerobic exercise results in physiological improvements, including improved lung function, these findings have not been consistent across all studies.

Fifth, little is known about the type, amount, and intensity of aerobic exercise that provides the greatest benefit to individuals with asthma. There is little consistency in these aspects of aerobic exercise across studies, making it difficult to determine the “optimal” level or type of aerobic exercise for individuals with asthma. Indeed, the existing literature has examined the impact of numerous types of aerobic exercise programs (e.g., circuit training, swimming, combined aerobic and strength training) on asthma and related symptoms and overall found physiological and psychological improvements; however, it is unclear which program provides the most benefit to individuals with asthma. Lastly, there is a need to examine the impact of psychosocial variables on asthma. For example, there have been no studies examining the impact of anxiety on aerobic exercise among individuals with asthma. Extant research indicates that anxiety negatively impacts both asthma and aerobic exercise [30-33]. Therefore, anxiety may be particularly detrimental for individuals with asthma attempting to exercise and may impact motivation to exercise, perceptions during aerobic exercise, and perceived benefits from aerobic exercise. Despite these limitations, however, the present review clearly documents the beneficial effects of aerobic exercise for individuals with asthma and highlights the importance of encouraging them to exercise regularly. Future work in this domain of study will lead to clinically relevant healthcare advances as well as the development of theoretically-driven, methodologically diverse lines of research exploring the asthma-aerobic exercise association.
Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.
References


<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Asthma Assessment</th>
<th>Physical Activity Assessment</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ford et al., 2003 [9]</td>
<td>165,123 adults with current (12,489), former (4,892) or no asthma (147,742) from the BRFSS</td>
<td>Self-report</td>
<td>Self-report; classified as (a) regular vigorous activity (i.e., requiring rhythmic contraction of large muscle groups at 50% functional capacity for at least 20 min ≥ 3 times/week; (b) regular activity (i.e., requiring less than 50% of functional capacity for at least 20 min ≥ 3 times/week; (c) irregular activity (i.e., less than 20 min or less than 3 times/week; and (d) physically inactive (i.e., engaging in no physical activity</td>
<td>Individuals with current asthma were more likely to be physically inactive. Individuals with current or former asthma were less likely to engage in more intense exercise.</td>
</tr>
<tr>
<td>Teramoto et al., 2011 [10]</td>
<td>3,840 adults living in Nevada participating in 2009 BRFSS</td>
<td>Self-report</td>
<td>Self-report; same classifications as Ford et al., 2003</td>
<td>Current and lifetime asthma diagnosis was associated with physical inactivity (OR = 3.01 and 2.17, respectively).</td>
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<tr>
<td>Malkia et al., 1998 [11]</td>
<td>7,193 adults with (178) and without asthma (7,015)</td>
<td>Self-report</td>
<td>Self-reported activities across settings (e.g., work, leisure, during commute); assigned a metabolic unit (MET) value from 1.5 to 10</td>
<td>Individuals with asthma engaged in lower intensity physical activity compared to those without asthma. Less intense physical activity was associated with lower levels of FEV₁, FEV₁%, and PEF.</td>
</tr>
<tr>
<td>Ford et al., 2004 [12]</td>
<td>12,111 adults with asthma from the BRFSS</td>
<td>Self-report</td>
<td>Self-report; same classifications as Ford et al., 2003</td>
<td>Physical inactivity or irregular physical activity was associated with greater physical and mental impairment and activity limitations.</td>
</tr>
<tr>
<td>Study</td>
<td>Sample Size</td>
<td>Study Design</td>
<td>Research Design</td>
<td>Findings</td>
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<tr>
<td>Strine et al., 2007 [13]</td>
<td>354,025 U.S. adults participating in the BRFSS</td>
<td>Self-report</td>
<td>Self-report; same classifications as Ford et al., 2003</td>
<td>Asthma more likely among individuals who were physically inactive (AOR = 1.2). Physical inactivity was associated with increased doctor (AOR = 1.5) and ED visits (AOR = 2.4), activity limitations (AOR = 1.7), asthma symptoms (AOR = 1.7), and inhaler use (AOR = 1.9).</td>
</tr>
<tr>
<td>Dogra et al., 2009 [14]</td>
<td>84,886 adults with (6,835) and without (78,051) asthma from CCHS</td>
<td>Self-report</td>
<td>Self-report, based on total daily energy expenditure classified as “inactive” (i.e., &lt; 1.5 kcal/kg of body weight per day), “moderately active” (i.e., 1.5 – 3.0 kcal/kg of body weight per day) and “active” (i.e., &gt; 3.0 kcal/kg of body weight per day)</td>
<td>Individuals with asthma who were inactive reported greater health care use within the last year.</td>
</tr>
<tr>
<td>Mancuso et al., 2006 [16]</td>
<td>60 adults with physician-verified asthma</td>
<td>Physician-verified diagnosis; prescription of daily asthma medication required</td>
<td>Self-reported attitudes and beliefs about exercise</td>
<td>Believed exercise was beneficial. Those with more severe asthma more likely to believe others with asthma should avoid physical activity. The majority of patients viewed having a chronic medical condition as a barrier to engaging in physical activity.</td>
</tr>
</tbody>
</table>

*Note. For Asthma Assessment, the term “physician-verified diagnosis” represents patients recruited from primary care clinics or hospitals with a prior diagnosis of asthma made by a physician. The term “self-report” was used for studies that asked participants in some way whether they had ever been diagnosed with asthma. For all studies, if objective measures were utilized to diagnose or confirm a diagnosis of asthma, it is specified.*
Table 2. Summary of studies examining asthma and exercise-related symptom perception and physiological responding

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Asthma Assessment</th>
<th>Physical Activity Assessment</th>
<th>Findings</th>
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<tbody>
<tr>
<td>Ergood et al., 1985 [17]</td>
<td>10 adolescent males with asthma and 10 age- and sex-matched controls</td>
<td>Physician-verified diagnosis; at least three documented asthma attacks with medical attention</td>
<td>Aerobic exercise performed for six minutes on ergometer cycle at workload sufficient to maintain heart rate of 60% of calculated maximum</td>
<td>No differences between subjective and objective (as measured by a peak flow meter) ratings of expiratory flow during aerobic exercise or at rest between those with and without asthma.</td>
</tr>
<tr>
<td>Mahler et al., 2006 [18]</td>
<td>Adolescents with (n = 14) and without (n = 33) asthma</td>
<td>Based on asthma history, current treatment, and pulmonary function testing (i.e., FEV₁/FVC &lt; 70% or ≥ 10% decrease in post-exercise FEV₁)</td>
<td>Incremental exercise test on cycle ergometer (15 watts/minute ramp protocol)</td>
<td>No group differences in associations between objective (as measured by spirometry and peak oxygen consumption) and subjective ratings of breathlessness during aerobic exercise.</td>
</tr>
<tr>
<td>Rietvelt et al., 2004 [19]</td>
<td>55 women: 19 with severe asthma, 18 with multiple physical symptoms, and 18 controls</td>
<td>Self-report; current asthma medication</td>
<td>15 minutes of cycling on a bicycle home trainer set at minimal resistance</td>
<td>No group differences in FEV₁. Individuals with asthma and individuals with multiple physical symptoms reported more subjective breathlessness than controls.</td>
</tr>
<tr>
<td>Study</td>
<td>Participants</td>
<td>Data Collection</td>
<td>Findings</td>
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<tr>
<td>Garcia-Aymerich et al., 2009 [3]</td>
<td>Longitudinal data from 2,818 women with asthma ages 30-55</td>
<td>Self-report; use of asthma medication within past 12 months</td>
<td>Greater physical activity associated with 25% decreased risk for asthma exacerbations (i.e., one or more asthma-related health care events including hospital admission, emergency room visit, urgent office visit)</td>
<td></td>
</tr>
<tr>
<td>Ritz et al., 2010 [4]</td>
<td>20 adults with asthma and 20 healthy controls</td>
<td>Physician-verified diagnosis</td>
<td>Among those with asthma, greater physical activity associated with improved PEF and FEV₁ values.</td>
<td></td>
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<tr>
<td>Tsai et al., 2011 [20]</td>
<td>27 Taiwanese adults with asthma and 27 age-and gender-matched controls</td>
<td>Physician-verified diagnosis mild to moderate asthma</td>
<td>Asthma was associated with poorer HRV. This effect was reduced among individuals who engaged in moderate to vigorous physical activity.</td>
<td></td>
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</tbody>
</table>

*Note. For Asthma Assessment, the term “physician-verified diagnosis” represents patients recruited from primary care clinics or hospitals with a prior diagnosis of asthma made by a physician. The term “self-report” was used for studies that asked participants in some way whether they had ever been diagnosed with asthma. For all studies, if objective measures were utilized to diagnose or confirm a diagnosis of asthma, it is specified.*
### Table 3. Summary of studies examining aerobic exercise as an intervention for asthma

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Asthma Assessment</th>
<th>Physical Activity Assessment/Condition</th>
<th>Findings</th>
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</thead>
<tbody>
<tr>
<td>Itkin et al., 1966 [21]</td>
<td>39 hospitalized patients with asthma</td>
<td>Physician-verified allergic asthma based on history, skin tests, removal and reexposure to allergen</td>
<td>Control condition: three-month participation in normal hospital activities, but no additional physical exertion; Aerobic exercise condition: three month aerobic exercise program consisting of 1 hour of calisthenics (e.g., stationary bicycle, sit ups) and 1 hour of planned sports activity daily for five days per week.</td>
<td>Aerobic exercise was not associated with increased medication utilization and resulted in improved athletic ability and lung function.</td>
</tr>
<tr>
<td>Robinson et al., 1992 [22]</td>
<td>8 individuals with moderate to severe asthma and 7 healthy controls</td>
<td>Physician-verified diagnosis</td>
<td>12 weeks of indoor circuit training consisting of a warm-up and between one and four circuits involving seven exercises completed for 50 seconds each with a 30-second rest in between</td>
<td>Circuit training was associated with increased peak oxygen uptake, improved lung functioning, increased regular physical activity, and greater perceived ability to perform physical tasks for both groups.</td>
</tr>
<tr>
<td>Emtner et al., 1996 [23]</td>
<td>26 adults with mild to moderate asthma</td>
<td>Physician-verified diagnosis of chronic well-controlled mild to moderate asthma; minimum of 20% reversibility in PEFR after treatment with β2-agonist</td>
<td>10-week supervised rehabilitation program consisting of 2 weeks of psychoeducation and daily indoor swimming exercises and 8 weeks of indoor swimming exercise twice a week. All sessions lasted 45 minutes</td>
<td>10-week aerobic exercise rehabilitation program resulted in improved lung and cardiovascular functioning and fewer asthma symptoms.</td>
</tr>
<tr>
<td>Mendes et al., 2010 [24]</td>
<td>101 individuals with moderate to severe persistent asthma ages 20-50</td>
<td>Physician-verified diagnosis of moderate to severe persistent asthma; diagnosis based on Global Initiative for Asthma</td>
<td>Control condition: 4-hour education program, breathing exercises for 30 minutes twice a week for 3 months; Exercise condition: completed all components of control condition and 3-month aerobic training program consisting of 30-minute session twice per week of</td>
<td>Aerobic exercise program resulted in improved HRQoL, reductions in state anxiety and depression, improvements in maximum oxygen consumption and number of symptom-free days.</td>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Intervention Details</td>
<td>Control Condition</td>
<td>Results</td>
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<tr>
<td>Mendes et al., 2011 [25]</td>
<td>68 patients with moderate to severe asthma</td>
<td>Physician-verified diagnosis of moderate to severe persistent asthma; diagnosis based on Global Initiative for Asthma</td>
<td>4-hour education program, breathing exercises for 30 minutes twice a week for 3 months; completed all components of control condition and 3-month aerobic training program consisting of 30-minute session twice per week of aerobic exercise on indoor treadmill completed at 60-70% VO$_{2}$max</td>
<td>Aerobic training program resulted in decreased airway inflammation, fewer ED visits, and more symptom-free days.</td>
</tr>
<tr>
<td>Dogra et al., 2011 [26]</td>
<td>36 adults with partially controlled asthma</td>
<td>Self-report; current prescription for asthma medication</td>
<td>Maintained current lifestyle throughout study; completed 12-week supervised exercise programs provided by qualified exercise professional consisting of 30 minutes of aerobic exercise and strength training three times per week followed by 12-week self-administered exercise program</td>
<td>Aerobic exercise intervention resulted in improved in asthma-related quality of life, asthma control, and aerobic fitness.</td>
</tr>
<tr>
<td>Goncalves et al., 2008 [27]</td>
<td>20 patients with moderate to severe asthma</td>
<td>Physician-verified diagnosis of moderate to severe asthma based on guidelines from Global Initiative for Asthma</td>
<td>4-hour education program and respiratory exercise program lasting 30 minutes twice per week for 3 months; completed all components of control condition plus aerobic training on treadmill (at 70% maximum power obtained in cardiopulmonary effort test) lasting 30 minutes twice per week for 3 months</td>
<td>Aerobic conditioning program resulted in more symptom-free days, improved quality of life, improved aerobic aptitude, decreased exhaled nitric oxide, and decreased anxiety and depression.</td>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Methodology</td>
<td>Results</td>
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<tr>
<td>Dogra et al.,</td>
<td>24 individuals with partly controlled asthma</td>
<td>Self-report; experience regular non-severe asthma symptoms and have current prescription for asthma medication</td>
<td>Control condition: maintained current lifestyle throughout study; Exercise condition: completed 12-week unsupervised exercise programs provided by qualified exercise professional consisting of 30 minutes of aerobic exercise, strength training, and stretching. Aerobic exercise program resulted in improved perceived asthma control and decreased frequency and severity of asthma symptoms. The program did not impact quality of life, objective measures of asthma control, and lung functioning.</td>
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<td>2010 [28]</td>
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<tr>
<td>Turner et al.,</td>
<td>34 adults over 40 years with moderate to severe</td>
<td>Self-reported diagnosis of moderate to severe asthma; evidence of fixed airflow obstruction by spirometry; stable asthma medication regimen; normal or raised gas transfer; activity limitations related to asthma</td>
<td>Control condition: usual care; Exercise condition: three 80-90 minute supervised exercise classes per week for 6 weeks, classes consisted of 10-15 minute warm-up, 20-minute walking training, 5-10 minute cool-down, 45-minute exercise circuit (cycle ergometer, step-ups, wall squats, upper limb endurance training). Supervised aerobic exercise intervention resulted in improvements in asthma-related quality of life but not lung functioning.</td>
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<td>2011 [29]</td>
<td>persistent asthma</td>
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*Note. For Asthma Assessment, the term “physician-verified diagnosis” represents patients recruited from primary care clinics or hospitals with a prior diagnosis of asthma made by a physician. The term “self-report” was used for studies that asked participants in some way whether they had ever been diagnosed with asthma. For all studies, if objective measures were utilized to diagnose or confirm a diagnosis of asthma, it is specified.*
Figure 1. Flow diagram illustrating study retrieval and selection.

Results identified from all databases
\(n = 5,665\)

Results excluded based on:
- Language \(n = 841\)
- Other species \(n = 294\)
- Age (children & adolescents) \(n = 2,542\)
- EIA/EIB \(n = 678\)
- Review article/Meta-analysis \(n = 993\)

Potentially relevant studies
\(n = 317\)

Results excluded due to relevance based on screening of titles and abstracts
\(n = 294\)

Studies included in the present review
\(n = 23\)