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Sveinung Berntsen, PhD, MCEP

Physical Activity in Childhood Asthma: Friend or Foe?

Abstract: *Physical activity has been considered as a double-edged sword for children with asthma. Children with asthma are recommended to participate in physical activities like their healthy nonasthmatic peers because regular physical activity positively affects psychological functioning, quality of life, morbidity, and aerobic fitness in children with asthma. However, uncontrolled asthma with ongoing exercise-induced bronchoconstriction may limit participation in sports, free play, and daily living. Observations also suggest that high-intensity exercise performed in cold air, seasonal allergens, pollutants, or respiratory virus infections may increase the risk for asthma in the highly active child. In contrast, a sedentary lifestyle has been highlighted as the explanation for the increased prevalence of asthma in the past decades. However, there is no consensus on whether a low level of physical activity increases the severity or risk of asthma. Use of asthma medications and good asthma control can make the conditions favorable for a physically active lifestyle and influence physical activity level and the level of aerobic fitness.*

Keywords: asthma; childhood; exercise; physical activity; recommendations

Introduction

It has been suggested that low levels of physical activity and aerobic fitness levels increase the risk of asthma in children.

healthy people, exercising intensely for long periods of time breathing large volumes of cold and/or dry air, air containing irritant gases, particulate matter, or allergens could result in the same airway response as documented in those with asthma. On the other hand, asthma with ongoing exercise-induced bronchoconstriction may limit participation in sports,

 **Comparisons of habitual physical activity levels of children and adolescents with and without asthma have given inconsistent results, with higher, lower, or similar physical activity levels reported in children and adolescents with asthma.** 

Paradoxically, observations also suggest that high-intensity exercise performed on a regular basis might contribute to the development of asthma in athletes previously unaffected by the disease. In

free play, and daily living. However, regular physical activity is reported to positively affect psychological functioning, quality of life, morbidity, and aerobic fitness in children with asthma, even

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The study is performed within the ORAACLE (the Oslo Research Group of Asthma and Allergy in Childhood; the Lung and Environment), which is part of the GA²LEN network. There are no competing or conflicts of interests.

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without changes in lung function or exercise tolerance.

This review first briefly gives an overview of whether children and adolescents with asthma are less physically active with lower aerobic fitness levels than their counterparts without asthma. Then, it examines whether sedentary behavior increases the risk for asthma during childhood. The last part discusses the potential benefits and risks of exercise before turning to physical activity and exercise recommendation for children and adolescents with asthma.

Asthma “Definitions” and Epidemiology

There is no clear definition of the asthma phenotype; however, asthma has been described as “a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role. The chronic inflammation is associated with airway hyperresponsiveness that leads to recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night or in the early morning. These episodes are usually associated with widespread, but variable, airflow obstruction within the lung that is often reversible either spontaneously or with treatment”.¹

A clinical diagnosis of asthma is suggested by symptoms such as episodic breathlessness, wheezing, cough, and chest tightness.² Episodic symptoms after an allergen exposure, seasonal variability of symptoms, presence of allergies and a positive family history of asthma are also helpful diagnostic guides. Ideally, diagnosis of asthma should be based on clinical evidence, which includes a detailed clinical history, respiratory assessment (including measurement of reversible airflow limitation and/or bronchial hyperresponsiveness), and consideration of differential diagnoses.²

Exercise-induced bronchoconstriction (EIB) can be seen as an indirect, non-specific bronchial hyperresponsiveness, and the magnitude of EIB is a measure of how well patients with asthma master it.³ EIB consists of bronchoconstriction occurring immediately or soon after

physical exercise and is thought to be a result of increased respiratory water and heat loss because of increased ventilation during exercise, with the subsequent release of mediators and stimulation of airway receptors.^{4,5}

The percentage of children and adolescents reported to ever have had asthma has increased in the past decades.⁶ Large variations in the prevalence of asthma symptoms have also been observed between centers worldwide in children and adolescents, with the highest prevalence in Western countries (8%-31%) and lowest in African (9%-20%), some east European (3%-23%), and Asian countries (3%-18%).⁷ It has been suggested that the current increase in asthma is occurring in children who would be regarded as at low risk of developing asthma, suggesting that much of the increase in asthma prevalence is occurring in children without a significant genetic predisposition.⁸ Asthma and asthma symptoms are also reported to be more common in elite athletes compared with age-matched controls.⁹⁻¹¹ The prevalence of EIB among children and adolescents in the general population has been reported to be 16% to 20%.^{12,13}

Does Physical Inactivity Increase the Risk for Asthma?

Physical activity can be defined as any bodily movement produced by the contraction of skeletal muscles that substantially increases energy expenditure^{14,15} and is characterized by its intensity, duration, frequency, and mode of activity.¹⁶ In contrast to physical activity, which is related to the movements performed, physical fitness has been defined as a set of attributes that people have or achieve and that are related to their ability to perform physical activity.¹⁴ Physical fitness comprises skill-related, health-related, and physiological components.¹⁵ Health-related components of physical fitness are cardiorespiratory endurance, muscular strength and endurance, flexibility, and body composition.¹⁴ Cardiorespiratory or aerobic fitness is related to the ability to perform large

muscle, dynamic, moderate- to vigorous-intensity exercise for prolonged periods.

In recent years it has been claimed that children and adolescents have reduced their level of physical activity and fitness.¹⁷ Physical activity in clearly defined contexts such as active transport or commuting to school, school physical education, and organized sports is declining in many countries,¹⁷ and the percentage of inactive adolescents seems to be rising.¹⁸ The increasing prevalence of asthma in Western societies in the past decades are thought to have a multifactorial explanation, including sensitization to allergens, lifestyle, and environment,¹⁹ with increasing attention to a “Western lifestyle,” including an unhealthy and sedentary lifestyle with decreased physical activity.²⁰

Comparisons of habitual physical activity levels of children and adolescents with and without asthma have given inconsistent results, with higher,^{21,22} lower,²³⁻²⁵ or similar physical activity levels²⁶⁻²⁸ reported in children and adolescents with asthma. In a large cross-sectional study, physical activity was associated with increased risk of current asthma in Norwegian children and adolescents exercising more than 7 hours a week,²⁶ whereas self-reported physical activity was not associated with a history of asthma. However, the prevalence of asthma symptoms was reported to be lower among inactive participants from the same study population.²⁹ This could suggest that those who are engaged in sports or exercise report asthma symptoms differently from those who are inactive. On the other hand, in the same cross-sectional study, the prevalence of bronchial hyperresponsiveness increased with decreasing hours of exercise per week only in children and adolescents with asthma.³⁰

Watching television for more than 3 hours per day was associated with more frequent asthma symptoms in 2290 Taiwanese children.³¹ An association between current asthma and sedentary behavior has also been reported in other American,^{32,33} Italian,³⁴ and Greek³⁵ studies. On the other hand, in a large study 15 years ago that included more than 7000 US children, the number of hours of television watching was not associated

with current asthma.³⁶ A high level of self-reported physical activity was associated with higher prevalence of diagnosed asthma in 636 US children,²¹ whereas participating in physical activity (self-reported) more than 3 times a week was associated with reduced occurrences of asthma symptoms in children in a large cross-sectional study from Taiwan.³¹ Only 4 studies reported objectively measured physical activity levels.^{25,27,28,37} Lower physical activity levels were reported in a small study in US children aged 3 to 5 years with a history of asthma symptoms,²⁵ whereas no differences in physical activity levels were found in a large study in Dutch children with undiagnosed asthma, those with diagnosed asthma, and controls.²⁷ Dutch children 4 to 5 years of age with current asthma symptoms were also reported to have similar activity levels compared with children with no symptoms ever.³⁷ However, asthma has been reported to interfere with children's ability to participate in vigorous physical activity.³⁸ In a German study, 254 teachers in 46 schools estimated that only 60% of the children and adolescents with asthma took part in physical education lessons on the same basis as their healthy peers.³⁹ This has been confirmed in an Australian study, where asthma negatively affected participation in sporting activities.⁴⁰

There is also contradictory evidence regarding aerobic fitness levels of children and adolescents with asthma. Reduced^{41,42} or similar^{28,43-45} aerobic fitness levels are reported in asthmatic subjects. Aerobic fitness is reported to be limited in adolescents with severe asthma.⁴² This is in contrast to other reports⁴⁶ that found no association between asthma severity and aerobic fitness. Physical inactivity has been suggested as an explanation for the lower levels of aerobic fitness in some adolescents with asthma.⁴⁷ A previous report indicates that the majority of severely asthmatic children with low levels of aerobic fitness can achieve a normal fitness after participation in a physical rehabilitation program.⁴⁸

Most reported studies have a cross-sectional design, and we cannot conclude that there is any causal relationship

between level of physical activity and asthma. However, in a prospective population-based study in asymptomatic Danish children, an inverse relationship between aerobic fitness (peak power output) and physician-diagnosed asthma was reported over the following 11 years.⁴⁹ The association between asthma and low aerobic fitness or physical activity levels reported in some studies^{23,41,42} could also have been a result of poor asthma control.⁵⁰ Those with asthma may limit the intensity of their physical activity because of dyspnea.⁵¹ However, engagement in significant levels of physical activity can lead to improved detection of asthma, particularly exercise-induced asthma. Consequently, physical activity levels in children and adolescents with asthma may appear artificially high because already active children and adolescents are more likely to be diagnosed as having asthma.⁵² The association can also be bidirectional, with low fitness leading to more asthma symptoms, which would then, in turn, lead to decreased effort and even lower fitness levels.

Potential Benefits of Physical Activity

Physical activity is reported to have positive effects on self-esteem in children and adolescents.⁵³ In unhappy children with asthma, quality of life and morbidity are reported to improve with low-intensity asthma education and exercise programs, even without changes in lung function or exercise tolerance.⁵⁴ Aerobic fitness is also reported to be positively associated with psychological functioning in asthmatic children.⁵⁵ In a Cochrane review, it was reported that physical training improved aerobic fitness without changing baseline lung function, exacerbations, or symptoms in children and adolescents with asthma.⁵⁶ However, recent published data indicate that regular physical training improves quality of life and asthma symptom scores in addition to aerobic fitness.^{57,58} Participation in regular physical activity and training also play an important role in the rehabilitation of asthmatic children^{3,59} because aerobic conditioning

lessens the prospect of an asthma attack by reducing the ventilatory requirement for any activity.⁶⁰ Although no change in airway inflammation was found in children with asthma after 12 weeks of aerobic training of moderate intensity (50 minutes, twice a week),^{61,62} bronchial hyperresponsiveness, a common manifestation of asthma, has been shown to be inversely related to physical activity in children.³⁰ A balance between the proinflammatory and anti-inflammatory effects of exercise in asthma has been suggested to be null in respect to markers of airway inflammation, such as fractional exhaled nitric oxide (FeNO).⁶¹ Whether regular physical activity reduces the degree of airway inflammation in children with asthma, thereby improving symptoms, and reduces the amount of medication required will have to be confirmed in future studies.

Potential Risks of Physical Activity

As many as 90% of children and adolescents with asthma not receiving anti-inflammatory treatment have been reported to have symptoms of asthma and reduction in lung function after physical exercise (EIB).^{63,64} Variation in environmental conditions, such as temperature and humidity of the inspired air, causes different patterns of bronchoconstriction after exercise. Inspiring cold, dry air during exercise led to increased bronchoconstriction.⁶⁵

Observations also suggest that high-level exercise performed on a regular basis might contribute to the development of asthma in athletes previously unaffected by the disease.⁶⁶ In healthy people, exercising intensively for long periods of time, breathing large volumes of cold and/or dry air, air containing irritant gases, particulate matter, or allergens could result in the same airway response as documented in those with asthma.⁶⁷ This was seen in a study that compared 19- to 21-year-old male competitive cross-country skiers with inactive controls who demonstrated increased bronchial hyperresponsiveness in the winter season.⁶⁸

The relationship between physical activity and asthma may be modeled in the form of a “J” curve. This model suggests that although the risk for asthma when one engages in regular physical activity of moderate to vigorous intensity may decrease below that of a sedentary individual, risk may rise to above average during periods when a large amount of high-intensity activity is performed under extreme conditions. A combination of endurance training and environmental hazards, such as cold air, seasonal allergens, pollutants, or respiratory virus infections, may increase the risk for asthma in athletes as well as in the highly active child.⁶⁹ In communities with high ozone concentrations, the relative risk of developing asthma in children participating in 3 or more types of sports was 3.3, compared with children playing no sports. Sports had no effect in areas with low ozone levels.⁷⁰ Recently, it was observed that children taking part in outdoor recreational activities have a significant increase in FeNO, related to ambient ozone levels.⁷¹ Participating in physical activity outdoors when pollution levels are high, children may also have higher relative exposures than adults.⁷²

In addition, large amounts of very vigorous physical activity has been associated with increased risk for upper-respiratory tract infections.⁷³ Endobronchial biopsies from competitive cross-country skiers without asthma showed markedly elevated numbers of lymphoid aggregates⁷⁴ and T-lymphocytes and also macrophage and eosinophil counts compared with nonasthmatic controls,⁷⁵ whereas FeNO was not changed after 12 weeks of aerobic training in children with mild asthma.^{61,62}

Recommendations

In 2005, an expert panel reviewed the literature on physical activity in children and adolescents and recommended participation in 60 minutes or more of moderate- to vigorous-intensity physical activity each day that is enjoyable and developmentally appropriate.⁷⁶ Children and adolescents with asthma are able

to participate in any physical activity if symptoms are well controlled.⁷⁷ Aerobic exercises like running,^{78,79} cycling,^{80,81} ball games,⁵⁸ and swimming^{82,83} have been suggested, and both moderate- and vigorous-intensity physical activity can be performed.⁸⁰ However, repeated exposure to irritant chlorine by-products may have some kind of harmful effect on the already-inflamed airways of asthmatic children.⁸⁴ In general, guidelines for children and adolescents with asthma regarding recommended frequency and duration are consistent with those given for healthy children.¹⁵ Only those with severe asthma need to modify their participation in physical activity or training routines.

Premedication, for example 200- μ g salbutamol or equivalent, at least 15 minutes prior to warm-up, should be taken, especially in children and adolescents in whom exercise may induce bronchoconstriction. Long-acting bronchodilator medication may be useful for younger children since exercise often is unstructured and spontaneous in this age group.

Since EIB may influence daily life activities and sports activities in children and adolescents, it is important to accurately diagnose EIB to enable optimal treatment. A commonly used and standardized testing protocol is running on a treadmill for 6 to 8 minutes at an exercise load of 95% of maximum heart rate (HR_{max}).⁸⁵ Cold air provokes exercise-induced bronchoconstriction and increases bronchial hyperresponsiveness and has to be kept in mind when participating in outdoor physical activity in such conditions.⁸⁶ However, using a face mask during physical activity in a cold environment may prevent or reduce EIB.^{87,88} Warm, humid air is also shown to minimize the development of EIB.⁸⁹

Children and adolescents with asthma should preexercise or warm up at moderate intensity ($<75\% HR_{max}$) for a few minutes.⁹⁰ Warm-up may reduce the need for medication before exercise.⁹¹

Care should also be taken during respiratory infections, and children and adolescents may need to avoid exercise and/or add medications at the onset of

a cold or upper-respiratory infection. Participating in physical activity outdoors in environmental conditions of polluted air or when airborne allergen levels are extremely high is not recommended.^{86,92} It should also be remembered that physically active children and adolescents are more exposed to pollutants and allergens in ambient air because of hyperventilation and inhalation of larger amounts of air.⁶⁹

Concluding Remarks

There is no consensus about whether a sedentary lifestyle or low level of physical activity increases asthma risk. Children with asthma should participate in physical activities because regular physical activity positively affects psychological functioning, quality of life, morbidity, and aerobic fitness in children with asthma. However, a combination of endurance training and an environmental hazard such as cold air, seasonal allergens, pollutants, or respiratory virus infections may increase the risk for asthma in highly active children and adolescents. Asthma may also interfere with the ability of children and adolescents to participate in physical activity. But use of asthma medications and good asthma control can make the conditions favorable for a physically active lifestyle and thereby positively influence their physical activity levels and level of aerobic fitness. **AJLM**

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