CE

Management of Exercise-Induced Bronchospasm in Adolescents with Asthma

Abstract: Physical activity in persons with asthma is important at any age but even more so in adolescents. Collaboration between the nurse practitioner and adolescent is essential to develop an asthma management plan that will provide for optimal physical activity and prevent asthma exacerbations while exercising.

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Asthma is a significant public health problem in the United States, with 7 million children in the United States affected.[1] It is one of the most common chronic diseases in children and frequently causes missed school days for children and missed work days for parents. Despite educational campaigns targeted at health professionals and the public, the burden of avoidable ED visits and hospitalization remains high. Asthma prevalence rates have continued to increase since 2000, and in 2006, boys between 11 and 17 years had a prevalence rate of 17%, as compared to girls of the same age with a prevalence rate of 11% [2]; Black children have a 42% higher prevalence than White children.[3] More than 14.4 million school days are missed annually due to asthma.[4] The overall death rate from asthma in children has decreased from 3.2 deaths per million in 1999 to 2.5 deaths per million in 2006.[4]

For people with asthma, physical activity is important at any age, but even more so in adolescents. In 2010, the American Lung Association reported that asthma is the leading cause of activity limitation in the United States. Asthma symptoms from poorly or undermanaged asthma can affect learning, physical activity, and even sleep in children and adolescents. The adolescent population has high rates of noncompliance to treatment as well as an active lifestyle in school, sports, and community activities, compounding the difficulty in managing asthma symptoms.

Asthma management of this population is challenging at best for the primary care NP, and collaboration between the NP and the adolescent is essential to develop an asthma management plan that allows optimal physical activity and prevents asthma exacerbations during exercise.

Defining asthma

Asthma is a complex disorder characterized by variable and recurring symptoms such as airflow obstruction, inflammation, and bronchial hyperresponsiveness.[5] Inflammation of bronchial smooth muscle causes an increase in the hyperresponsiveness of airways and, when stimulated, leads to

Key words: asthma, bronchoconstriction, exercise-induced asthma

airway constriction and obstruction. The obstruction produces symptoms of wheezing; breathlessness; pain, pressure, or tightness in the chest; and cough. The exaggerated bronchoconstriction response to stimuli (airway hyperresponsiveness) and swelling of the airway causes increased mucus production that leads to the formation of mucous plugs, which cause further obstruction (see *Bronchial changes in asthma*). Chronic untreated or poorly managed asthma can lead to airway remodeling. This occurs when airway inflammation is not controlled, the smooth airway muscles thicken and become less responsive to bronchodilation. Over time, this leads to a decline in lung function.[6] The interplay of these symptoms determines the severity of asthma.

Exercise triggers symptoms in most asthmatic patients and in many, it is the only prominent cause.

Underlying factors can contribute to the development of asthma. Research indicates that asthma may be hereditary. There also has been a correlation with environmental factors such as air quality, including indoor and outdoor environmental conditions that can be affected by pets, house dust, mold, and secondhand smoke.[7]

Diagnosis

A thorough history is important when diagnosing asthma. A patient who has had frequent lower respiratory infections as a child, a family history of asthma and atopic disease, and exposure to secondhand smoke in the home may be asthmatic. Other factors include presentation of symptoms related to exposure to allergens and relationship of worsening of symptoms due to the change in seasons.[8] Current symptoms of wheezing, coughing (especially at night), chest tightness, and breathlessness including during exercise should also be evaluated.

The physical exam should focus on the upper respiratory tract for evidence of allergies, such as increased nasal secretion, mucosal swelling, and nasal polyps. Because asthma may be stimulated by the presence of allergens, the skin should also be evaluated for atopic dermatitis and eczema. NPs should also note whether wheezing is present during normal breathing or during a prolonged phase of forced exhalation and if hyperexpansion of the thorax is present.[5] A patient may not exhibit all of the symptoms simultaneously.

Spirometry testing, which measures strength and volume of exhalation, is considered the most objective means of establishing an asthma diagnosis. Spirometry testing pre- and post administration of a bronchodilator can establish the level of airway obstruction and whether treatment can alleviate the problem. Reversibility in an adolescent with asthma will show an increase in the FEV_1 (forced expiratory volume at 1 second) greater than 12% over the prebronchodilator measurement.[5]

Additional testing may be necessary to confirm or exclude a diagnosis of asthma. Methacholine (Provocholine), a bronchoconstrictor, is used to induce symptoms of bronchoconstriction, and the patient's lung capacity is again measured before and after spirometry testing (the methacholine challenge is usually administered if the spirometry test with bronchodilation is inconclusive). A positive test is consistent with a diagnosis of asthma.[5] This type of testing is usually performed by an allergist or pulmonologist.

Allergy testing may also be of value due to the strong relationship between allergies and asthma. Allergy testing may be done by skin testing, which is generally not performed in primary care, or measurement of serum IgE, which can be tested easily at the primary care office.[8] Referral to an allergist or pulmonologist should be considered for the adolescent with persistent symptoms that have not been controlled adequately as evidenced by frequent exacerbations. Adolescents who present with environmental allergies that contribute to their asthma symptoms should also be referred to an allergist.[9]

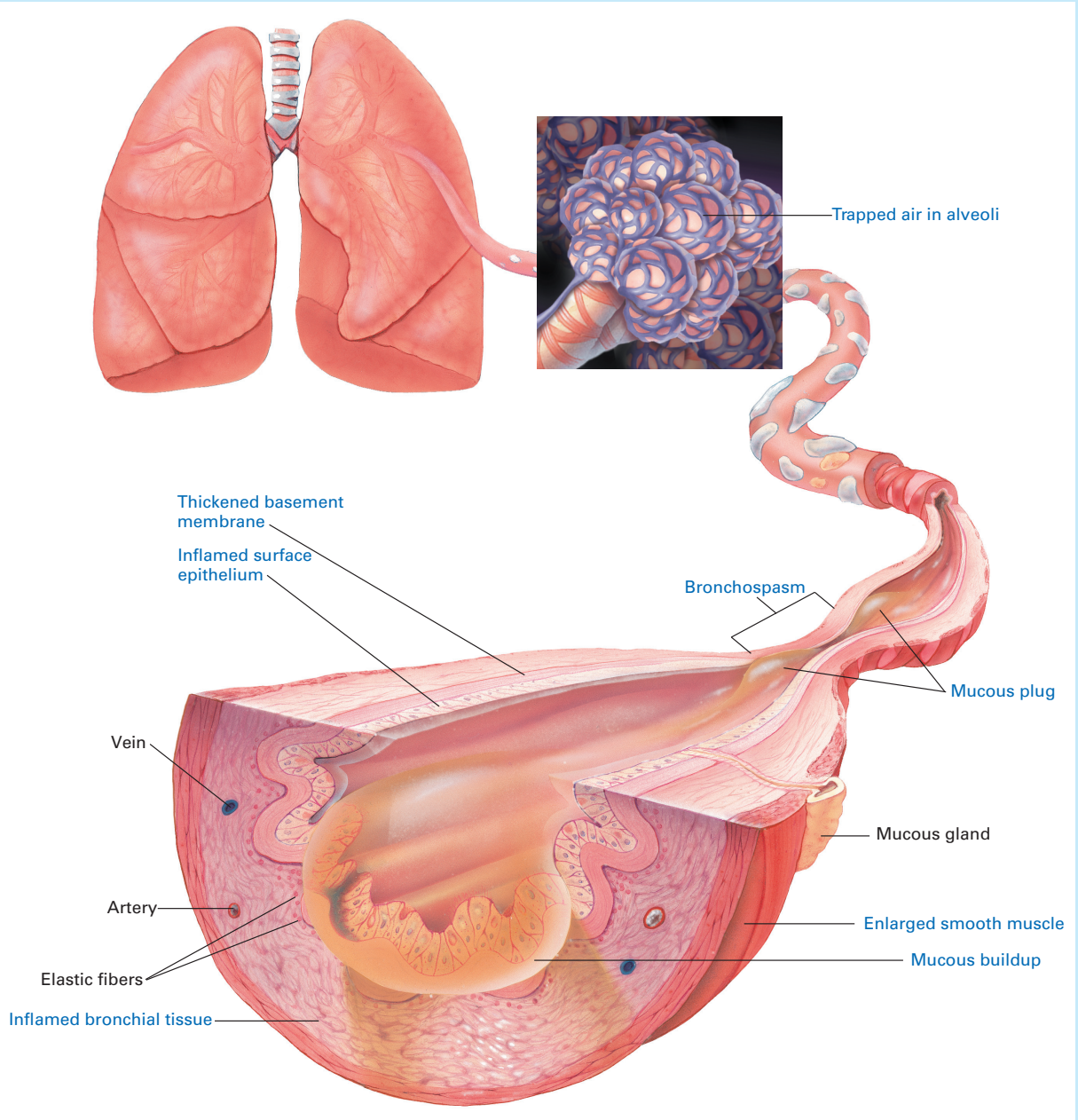
Differential diagnoses include vocal cord dysfunction, gastroesophageal reflux disease, hyperventilation syndrome, or sleep apnea. Tuberculosis may be a consideration in some high-risk populations.

Exercise-induced asthma in adolescents

Adolescents are routinely involved in a high level of physical activity, both during school and on after-school community teams. The ability to participate in physical activity both during school and in extracurricular activities can affect the student's quality of life, physical health, and also learning. Improved quality of life and physical well-being are both positive outcomes of physical activity in adolescents with asthma.[10] One area of concern with adolescents is exercise-induced bronchospasm, also known as exercise-induced asthma, which is an airway obstruction or a temporary increase in airway resistance that occurs during or after exercise.

Exercise triggers symptoms in most asthmatic patients, and in many it is the only prominent cause. It most commonly causes shortness of breath, increased respiratory effort, coughing, or wheezing during episodes of increased physical activity that can lead to an acute asthma exacerbation.[11] Exercise-induced bronchospasm can be seen in those with

Bronchial changes in asthma



Source: The Anatomical Chart Company. *Atlas of Pathophysiology.* 3rd ed. Philadelphia, PA: Wolters Kluwer/Lippincott Williams & Wilkins; 2010.

chronic asthma as well as in those who do not have daily asthma symptoms.[12] Eighty to 90 percent of asthmatic patients experience some form of exercise-induced bronchospasm, along with 40% of people with allergic rhinitis and 10% of the general population.

The pathology of exercise-induced bronchospasm has been studied extensively with two consistent hypotheses. The first hypothesis is known as the hyperosmolarity theory. This theory postulates that the water loss that occurs during increased respirations while exercising dehydrates the bronchial mucosa. This leads to an increase in the osmolarity by increasing the number of solutes in the mucosal fluid. This causes the mucus to become thick and difficult to cough out of the bronchi. The mast cells, which are inflammatory mediators,

are activated and this leads to bronchial constriction and subsequent symptoms of coughing, wheezing, or dyspnea.[13]

The airway rewarming theory hypothesizes that the airways cool and lose water during exercise. The airways rewarm after exercise and the small bronchiolar vessels that wrap around the bronchial tree dilate. This leads to congested vessels and fluid exudation movement into the submucosa of the airway, which triggers a mediator response and bronchoconstriction. Neither of these two theories considers the underlying inflammation of chronic asthma as a factor in exercise-induced bronchospasm.[14] Some variables that may affect the severity of exercise-induced bronchospasm are the condition of the air (cold, dry, or polluted), the type of exercise, deconditioning, and current asthma control. The presence of respiratory tract infection and last episode of exercise-induced bronchospasm are also factors.[15]

The type of exercise can also determine whether a patient may have an asthma attack. Vigorous exercises are more likely to be asthmogenic, causing an exercise-induced bronchospasm, than less vigorous exercises.[11] This may be related to the level of ventilation that is achieved during exercise and how long it is sustained. The water content in the air is also a factor. Cool, dry air may cause a more severe response than warm, moist air. Cold weather sports, such as ice hockey and cross-country skiing, appear to cause exercise-induced bronchospasm more frequently than those performed in warm environments. For example, a high school student playing football in Colorado may have more problems with symptom management than his peer who is on the golf team in Florida. Asthmatic swimmers are less likely to have exercise-induced bronchospasm than asthmatics participating in outdoor sports.[16] Sports that have periods of prolonged intense exercise, such as basketball and soccer, are more asthmogenic than sports that have brief periods of intense activity followed by a period of rest, such as football and baseball. This may be related to sustained rapid respirations that occur with intense sports.[13]

The airway rewarming theory hypothesizes that airways cool and lose water during exercise.

Obesity may be another factor as recent studies indicate a correlation between obesity and asthma symptoms. There has been no correlation found between exercise-induced bronchospasm and obesity. However, asthma symptoms may be more pronounced during exercise in the obese adolescent patient. When a person is obese, the increased abdominal fat restricts movement of the diaphragm leading to under expansion of the lungs and smaller inspiratory breaths. Also, research has found that fat cells tend to hold and increase the inflammatory markers in the body, which leads to a constant state of systemic low-grade inflammation. Thus, while the relationship is not clearly understood, adolescents who are obese and have asthma generally suffer more severe asthma than normal-weight adolescents with asthma.[17] Obesity can make it more difficult to diagnosis and treat asthma due to such as shortness of breath resulting from deconditioning or decreased lung volumes. These may be perceived as symptoms of obesity when they are actually due to asthma.

Pharmacologic treatment

The management of exercise-induced bronchospasm may include both pharmacologic and nonpharmacologic treatments. In March of 2010, South Dakota became the 50th state to pass legislation allowing students to carry inhalers in school. This allows students with exercise-induced bronchospasm to use inhalers before physical education classes; however, individual schools have policies that regulate the student's ability to possess an inhaler during school hours.[18] An important component of pharmacologic treatment in asthma is patient education. The adolescent should receive instruction on proper device technique including return demonstration of any medications that are prescribed. This improves compliance with inhaled asthma medications, leading to decreased asthma exacerbations.[19] Improved compliance should also improve tolerance of physical activity.

The most common treatment is a short-acting $beta_2$-agonist (rapid acting), such as albuterol (Proventil) or levalbuterol (Xopenex), which is administered via metered-dose inhaler about 15 to 30 minutes before exercise. The peak effect of the medication occurs between 15 to 60 minutes and may last for 3 to 4 hours. While albuterol or levalbuterol is recommended for relief of acute symptoms, some students may feel awkward or embarrassed using their inhalers in front of others, and some misinformed school personnel may also contribute to a child's noncompliance with inhaler usage.[20] When short-acting $beta_2$-agonists are not effective in controlling symptoms of exercise-induced bronchospasm, medications used for daily control of general asthma symptoms may be necessary. Some long-acting $beta_2$-agonists, such as salmeterol (Serevent Diskus) and formoterol (Foradil), have been evaluated for use as second-line treatment. Salmeterol should be taken at least 30 minutes before exercise. Formoterol should be taken 15 minutes before starting activity.[21]

In November 2005, the FDA announced a requirement for the inclusion of new packaging for long-acting beta$_2$-agonists that alerted consumers to the increased risk of death when using these drugs, as well as a warning to prescribers that they should not be used as first-line treatment, nor without the use of inhaled corticosteroids. By July 2006, all manufacturers complied.[22]

Cromolyn sodium oral inhalation (Intal) is a mast cell stabilizer used to treat asthma and is also prescribed for exercise-induced bronchospasm. Mast cell stabilizers block histamine release, which decrease the inflammatory response that leads to bronchospasm. The onset of action is immediate, but duration is approximately 2 hours. The drug causes less tachycardia, and may be preferred in some cases.[23]

Leukotriene receptor antagonists (LTRAs) (zafirlukast [Accolate] and montelukast [Singulair], and the leukotriene formation inhibitor, zileuton [Zyflo]) have also been studied in exercise-induced bronchospasm. During exercise it has been hypothesized that leukotrienes are released due to cooling and drying of the airways. LTRAs appear to mediate the leukotriene response, a component of bronchoconstriction in exercise-induced bronchospasm. The protective effect begins approximately 1 hour after ingesting the medication (usually in tablet form) and lasts from 8 to 12 hours. They are well tolerated with few adverse effects and are recommended as a potential add-on therapy to a bronchodilator.[24]

The National Heart, Lung, and Blood Institute (NHLBI) recommends the use of inhaled corticosteriods for mild persistent asthma.[5] Several studies recommend the use of inhaled corticosteriods for exercise-induced bronchospasm that is not relieved by short-acting beta$_2$-agonists, especially if the degree of exercise-induced bronchospasm interferes with physical activity.[12] These medications, routinely administered via inhaler once or twice daily, include flunisolide (Aerobid), ciclesonide (Alvesco), mometasone (Asmanex), triamcinolone (Azmacort), fluticasone (Flovent), budesonide (Pulmicort), and beclomethasone (Qvar).

NPs should teach adolescents about their medications while establishing goals for physical activity. Adolescents should understand the need to use medications appropriately and that quick relief medications should be used as needed to prevent EIB or during episodes of acute distress. The controller medications should be used daily to prevent exacerbations and decrease the inflammation in the lungs.

Nonpharmacologic treatment

Nonpharmacologic treatment to avoid an attack includes performing warm-up exercises before the activity, choosing an appropriate activity level for the patient, and switching from breathing through the mouth to breathing through the nose. Education regarding control of indoor allergens should be included in any asthma management plan and reviewed with the parents at regular intervals, especially if there is an increase in the frequency of asthma exacerbations. Dust mites are the most prevalent indoor trigger for asthma; however, pets, mold, and secondhand smoke are also contributors.[25]

A warm-up period has been related to decreased symptoms of exercise-induced bronchospasm during exercise, thus improving exercise tolerance. Warm-up exercises need to be performed for 10 to 15 minutes before the onset of the planned activity where the goal is to reach 50% to 60% of the maximum heart rate. Exercise programs can be designed to meet the needs of the individual and increase exercise capacity and tolerance.[26] By breathing through the nose, the air is warmed and moistened and less irritating to the lungs. Patients can also choose sports or activities that are performed in more appropriate environments; for example, swimming (in a warm, humid environment) would be a better choice than ice hockey (in a cold, dry environment).

Research has found nonadherence rates as high as 60% in pediatric and adolescent populations.

While aerobic conditioning can lead to decreased symptoms of exercise-induced bronchospasm by reducing the ventilatory requirements during exercise, adolescents must understand that this may not eliminate the problem. For some asthmatic patients, a combination of pharmacologic and nonpharmacologic therapy may be beneficial to exercise tolerance.[24]

Compliance with treatment

Adherence with disease management is a common problem with chronic diseases, and, historically, the adolescent population has a high degree of nonadherence.[27] Research has found nonadherence rates as high as 60% in pediatric and adolescent populations.[28] Lack of adherence to inhaled corticosteroids increases morbidity in adolescents between 15 to 19 years of age who perceive that the medication does not help symptoms.[29] Other reasons for nonadherence with inhaled corticosteroid treatment were: "It tastes bad," "I don't have time to take it," and general denial of the need to treat asthma symptoms.

An important component of adherence to medication is accurate assessment of asthma symptoms by the patient and his family. If patients or their guardians do not perceive asthma

My Asthma Plan

ENGLISH

Patient Name:_____

Medical Record #:_____

Provider's Name:_____ DOB:_____

Provider's Phone #:_____ Provider's Signature:_____Date:_____

Controller Medicines	How Much to Take	How Often	Other Instructions
		_____ times per day **EVERY DAY!**	☐ Gargle or rinse mouth after use
		_____ times per day **EVERY DAY!**	
		_____ times per day **EVERY DAY!**	
		_____ times per day **EVERY DAY!**	
Quick-Relief Medicines	**How Much to Take**	**How Often**	**Other Instructions**
	☐ 2 puffs ☐ 4 puffs ☐ 1 nebulizer treatment	Take ONLY as needed (see below—starting in Yellow Zone or before excercise)	NOTE: If you need this medicine more than two days a week, call physician to consider increasing controller medications and discuss your treatment plan.

Special instructions when I am 🟢 *doing well,* 🟡 *getting worse,* 🔴 *having a medical alert.*

GREEN ZONE

Doing ***well.***

- No cough, wheeze, chest tightness, or shortness of breath during the day or night.
- Can do usual activities.

Peak Flow (for ages 5 and up):
is _____or more. (80% or more of personal best)
Personal Best Peak Flow (for ages 5 and up):____

PREVENT asthma symptoms every day:

- ☐ Take my controller medicines (above) every day.
- ☐ Before exercise, take____puff(s) of _____
- ☐ Avoid things that make my asthma worse.

YELLOW ZONE

Getting ***worse.***

- Couth, wheeze, chest tightness, shortness of breath or
- Waking at night due to asthma symptoms, or
- Can do some, but not all, usual activities.

Peak Flow (for ages 5 and up):
_____to_____ (50 to 79% of personal best)

CAUTION Continue taking every day controller medicines, AND:

- ☐ Take____puffs or ☐ one nebulizer treatment of quick relief medicine. If I am not back in the Green Zone within 20–30 minutes take____more puffs or nebulizer treatments. If I am not back in the Green Zone within one hour, then I should:
- ☐ Increase_____
- ☐ Add_____
- ☐ Call_____
- ☐ Continue using quick relief medicine every 4 hours as needed. Call provider if not improving in ____days.

RED ZONE

Medical Alert

- Very short of breath, or
- Quick-relief medicines have not helped, or
- Cannot do usual activities, or
- Symptoms are same or get worse after 24 hours in Yellow Zone.

Peak Flow (for ages 5 and up):
less than_____ (50% of personal best)

MEDICAL ALERT! Get help!

- ☐ Take quick relief medicine:_____puffs every_____minutes and get help immediately.
- ☐ Take_____
- ☐ Call_____

Danger! Get help immediately! Call 911 if trouble walking or talking due to shortness of breath or if lips or fingernails are gray or blue. For child, call 911 if skin is sucked in around neck and ribs during breaths or child doesn't respond normally.

Health Care Provider: My signature provides authorization for the above written orders. I understand that all procedures will be implemented in accordance with state laws and regulations. Student may self carry asthma medications: ☐ Yes ☐ No self administer asthma medications: ☐ Yes ☐ No (This authorization is for a maximum of one year from signature date.)

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symptoms as severe, it may lead to a delay in seeking treatment for acute and chronic symptoms.[30] Parental belief factors can also affect adherence to treatment. Parents who believe that inhaled corticosteroids are an important component of treatment are more likely to facilitate adherence in the adolescent.[28]

Although adolescents who have a good support system of family and health professionals tend to be more adherent to treatment plans, research has demonstrated that adherence declines over time without regular evaluation of symptom management, patient education, and reinforcement of asthma treatment plan.[31,32] The asthma action plan gives adolescents the tools they need to manage their asthma and promotes self-efficacy. The plan should involve the NP, adolescent, and family for optimal compliance. Repeated studies consistently indicate improved outcomes when asthma action plans are used. Students with action plans have fewer missed school days, fewer ED visits, and fewer hospitalizations.

An important component of the asthma action plan is the use of peak flow meters.[33] First, the patient must establish a personal best by measuring peak expiratory flow both pre and post use of a bronchodilator morning and evening for a 2-week period. The highest value consistently achieved is considered to be the personal best for that patient. Patients can create an individualized green–yellow–red zone indicator for their asthma action plan that can indicate when treatment changes are needed and what actions to take. A peak flow of more than 80% of personal best is in the green zone (good, continue treatment as planned), the yellow zone is a range of 50% to 80% (adjustment to treatment needed), and the red zone is less than 50% (medical emergency). Asthma action plans based on personal best peak expiratory flow have been found to decrease ED visits and hospital admissions.

Some adolescents may prefer a symptom-based asthma action plan. These plans can show worsening symptoms, such as increased dyspnea or wheezing or the inability to say a complete sentence without stopping to breathe, as indicators to seek medical treatment.

The plan should be collaborative, easy to use, and sensitive to any cultural or literacy needs. Reviewing the asthma action plan at each visit will reinforce its necessity and allow for adjustments to the plan. A copy of the asthma action plan should be kept at home, school, and for traveling to camp or sleepovers with friends.[32] There are many different templates available online provided by the American Lung Association, Association of Asthma Educators, and the NHLBI (see *My Asthma Plan* for a sample asthma action plan developed by the Regional Asthma Management and Prevention program).

Conclusion

Asthma continues to be a growing problem in the United States, and adolescents with asthma have specific problems and needs related to the management of the disease. A physically active adolescent is less likely to experience obesity and its inherent risk of comorbidities. The adolescent population is also historically noncompliant when managing chronic disease, and those who participate in athletics may have added social difficulties. The added peer pressure of using an inhaler before playing and a possible unwillingness to admit experiencing symptoms can increase the risk of death from acute exacerbation.

The asthma management and action plans must be developed in collaboration with the adolescent, parents, and NP.

The NP has a key role in routine assessment, modification of the treatment plan, and patient education. Inhaler techniques and asthma control should be assessed at each visit. The asthma management plan and asthma action plan must be developed in collaboration with the adolescent, parent, and NP. Special attention should be given to the desired level of physical activity so the adolescent can participate to the fullest extent of his abilities and continued reinforcement of the importance of controlling asthma symptoms may help to maintain adherence to medication in the adolescent. NP

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