Austin Journal of Pulmonary & Respiratory Medicine

Open Access

Austin Publishing Group

Review Article

Exercise-Induced Bronchoconstriction in Athletes

Serghei Covantev, Alexandru Corlateanu* and Victor Botnaru
Department of Respiratory Medicine, State University of Medicine and Pharmacy "Nicolae Testemitanu", Moldova

***Corresponding author:** Alexandru Corlateanu, Department of Respiratory Medicine, State University of Medicine and Pharmacy "Nicolae Testemitanu", Stefan Cel Mare Street 165, 2004, Chisinau, Moldova

Received: November 30, 2015; **Accepted:** March 01, 2016; **Published:** March 04, 2016

Abstract

Exercise-induced bronchoconstriction is a disease with high prevalence among elite athletes and it can be up to 70%. Diagnosing this condition is essential to accurately manage the condition preserving excellent lung function among athletes. In this article is presented a review of studies on exercise-induced bronchoconstriction, methods of diagnosis and management.

Keywords: Exercise-induced bronchoconstriction; Elite athletes

Introduction

Exercise-Induced Bronchoconstriction (EIB) describes acute airway narrowing that occurs as a result of exercise. It can occur in patients with asthma as well in patients who were previously not diagnosed with the disease [1]. Many studies have been performed in elite-level athletes that have documented prevalence of EIB varying between 30 and 70%, depending on the population, sport type, studied and methods implemented but no relationship were currently found regarding height, weight, age and gender [2-5]. The clinical symptoms of EIB include coughing, wheezing, chest pain and dyspnoea following an exercise but can often can be absent or not noticed by the athlete. Further examination often reveals some degree of atopy [6]. But it should be noted that self-reported symptoms are not always present and asymptomatic forms are very common [7].

Highly trained athletes tend to be frequently and for a long period of time exposed to cold air during winter training, to pollen allergens in spring and summer, different chemical substances used as disinfectants in swimming pools. These factors probably explain why elite athletes so often have EIB. This condition is most commonly found in endurance sports, such as cycling, swimming, or long-distance running. The occurrences of exercise-induced bronchospasm vary from 3% to 35% and depend on testing environment, type of exercise used, and athlete population tested. Still the highest risk for developing EIB in swimmers may be even higher, being 36%-79% [8].

Causes, Inflammatory State and Risks of EIB

The causes of EIB are not completely understood. Several theories have been developed during the years such as thermal and osmotic. Thermal hypothesis proposed that when prolonged cooling of the airways is followed by rapid rewarming it can result in vasoconstriction and a reactive hyperemia of the bronchial circulatory system [3,9]. The osmotic hypothesis proposes that as water is evaporated from the airway surface liquid; it becomes hyperosmolar and provides an osmotic stimulus for water to move from any cell nearby, causing cell volume loss and eventually an increased secretion of inflammatory mediators [3,9].

Still there are several immune mechanism implicated in EIB development. Several studies show that eosinophils, neutrophils and basophils migrate and cause airway inflammation, plus the number of neutrophils correlated with the number of training hours per week [10-12].

The majority of elite athletes show evidence of bronchial epithelial damage and other studies performed in animals and people indicate upregulation of pro-inflammatory cytokines, damage of small airways in mice, neutrophilic and lymphocytic inflammation with remodelling in bronchial biopsies [11,13].

Expose of smooth muscle to inflammatory substances over time can lead to changes in the contractile properties of the smooth muscle, making it more sensitive to mediators of bronchoconstriction [14].

Six hundred and fifty-nine Italian Olympic athletes were studied through four cross-sectional surveys performed during 12 years. The prevalence of asthma and/or EIB was 14.7%, with a significant increase from 2000 (11.3%) to 2008 (17.2%). The prevalence of rhinitis was 26.2%, conjunctivitis - 20%, skin allergic diseases - 14.8% and anaphylaxis - 1.1%. In 2000 sensitization to inhalant allergens was 32.7% and in 2008 it increased to 56.5%. Food, drug and venom allergy was present in 7.1%, 5.0% and 2.1% of athletes, respectively. Asthma and allergy was associated with recurrent upper respiratory tract infection in 10.3%, herpes infection in 18.2%, an abnormal T cell subset profile and a general down-regulation of serum cytokines level [15].

A study that involved 1680 Norwegian athletes and a 1680 random sample from the general population showed that the prevalence of asthma among athletes was 10% compared with 6.9% in the general population and remained so after controlling for confounders. The risk of asthma was highest in sports requiring strength and endurance. Asthma was more common among female than male athletes. Training more than 20 hours per week was associated with asthma when compared with levels of training less than 10 hours per week [16].

It is important to mention that EIB is probably a reversible condition. Forty-two elite competitive swimmers, most of them from the Finnish national team were followed for 5 years in a prospective manner. In swimmers who had stopped high-level training, bronchial hyper responsiveness attenuated or even disappeared. On the other hand mild eosinophilic airway inflammation was aggravated among highly trained swimmers who remained active during the 5-year follow-up [17].

Citation: Covantev S, Corlateanu A and Botnaru V. Exercise-Induced Bronchoconstriction in Athletes. Austin J Pulm Respir Med 2016; 3(1): 1037.

Table 1: Levels of EIB severity.

Grade	FEV1 fall
Mild	More than 10% but less than 25%
Moderate	More than 25% but less than 50%
Severe	More than 50%

Table 2: Diagnostic procedures for EIB and Asthma in athletes.

Procedure	Criteria
Pulmonary function	FEV_1 <70 %, FEV_1/VC <55 %
Bronchodilator test	↑ FEV_1 ≥ 12 % and >200 ml
Eucapnic Voluntary Hyperpnea (EVH)	↓ FEV_1 ≥ 10 %
Exercise challenge	↓ FEV_1 ≥ 10 %
Methacholine challenge	↓ FEV_1 ≥ 20 % with a: - PC_{20} ≤ 4 mg/ml (for subjects not taking ICS or - PC_{20} ≤ 16 mg/ml (for subjects taking ICS for at least 1 month)
Hyperosmolar test (Mannitol, Saline)	↓ FEV_1 ≥ 15 %

Diagnosing EIB in Athletes

The diagnosis of EIB is established by changes in lung function provoked by exercise, not on the basis of symptoms. Serial lung function measurements after a specific exercise or hyperpnea challenge are used to determine if EIB is present and to quantify the severity of the disorder. Forced Expiratory Volume in first second (FEV1) is used to diagnose this syndrome because this measurement has better repeatability and is more discriminating than peak expiratory flow rate. The airway response is expressed as the percent fall in FEV1 from the baseline value. The difference between the pre-exercise FEV1 value and the lowest FEV1 value recorded within 30 minutes after exercise is expressed as a percentage of the pre-exercise value. The criterion for the percent fall in FEV1 used to diagnose EIB is >10%. Several levels of EIB are described by American Thoracic Society (ATS) and are presented in Table 1 [1].

A number of surrogates for exercise testing have been developed that may be easier to implement than exercise challenge such as methacholine challenge, Eucapnic Voluntary Hyperpnoea (EVH) test, Field-Based Exercise Test (FBT) and a Laboratory-Based Exercise Test (LBT) but EVH test remains the most sensitive test for identifying EIB in elite athletes [1,18-22]. The International Olympic Committee has several recommendations for diagnosing EIB in athletes to permit the use of anti-asthmatic drugs: a positive clinical history and at least one positive diagnostic test (Table 2) [23].

Since the pathogenesis of EIB in elite athletes might be different from that of asthma, the methacholine challenge test doesn't always give the possibility to indentify EIB [21]. Other authors on the contrary recommend performing both methacholine challenge and EVH test in some groups of athletes since the exact mechanism of EIB is not completely understood and several factors may be involved in the development of this disease [24]. Finally another opinion exists that one EVH test is not enough and several tests should be performed especially in patients with borderline results to rule out possible misdiagnosis [25].

In general EVH is considered to be a more sensitive and specific test. A disadvantage is considered the need to monitor minute ventilation and that it is relatively expensive [26,27].

EVH should be also used as a screening method in athletes without EIB symptoms since not all athletes report having breathing difficulties but it can affect their performance and life quality [28]. Impulse oscillometry with indirect bronchoprovocation testing is another method for the diagnosis of airway dysfunction in athletes but it tends to detect additional cases of airway dysfunction in athletes [29].

In a study that involved 228 elite British athletes for EIB using EVH 78 athletes (34%) demonstrated EVH positive. Fifty seven out of the 78 (73%) athletes who demonstrated EVH positive did not have a previous diagnosis of EIB [30]. Of the 107 elite Tunisian athletes 1.8% reported previously having asthma but post-exercise spirometry revealed the presence of EIB in 14 (13%) of the athletes [31].

Additionally it should be noted that seasonal variability affects the occurrence of EIB, and thus exercise testing should be performed in both cold winter air and the pollen season to detect EIB in runners. Out of 58 elite runners, from Finnish national teams 9 (22%) of the 41 runners, challenged in both the winter and the pollen season, had probable EIB only in the winter, and 3 (7%) had it only in the pollen season whereas only one runner (2%) had EIB in both tests [32].

Management of EIB in Athletes

Several drugs are typically used in EIB such as Short-Acting Beta 2 Agonist (SABA), Long-Acting Beta 2 Agonists (LABA), Inhaled Corticosteroids (ICS), Leukotriene Receptor Antagonists (LRA), Mast Cell Stabilizing Agents (MCS) and Inhailed Anticholinergic Agents (IAA) and possibly also Antihistamines (AH) (Table 3) [1,33].

A randomized, active-controlled and placebo-controlled, double-blind, double-dummy, three-way crossover study was conducted in 47 patients in whom there was a 20 to 40% fall in FEV1 following exercise. Patients received oral montelukast (10 mg), placebo, or inhaled salmeterol (50 μg). Dosing was followed by exercise challenges at 2, 8.5, and 24 hours. Montelukast and salmeterol had similar efficacy at 2 and 8.5 hours, but only montelukast was effective at 24 hours. Thus as a conclusion montelukast provided significant protection against EIB having an onset within 2 hours following a single oral dose and lasting for at least 24 hours [34].

The current ATS recommendations are to use daily inhaled ICS or a daily leukotriene receptor antagonist which leaves mast cell stabilizing agents and inhaled anticholinergic as secondary role drugs [1].

The use of any drug should be monitored carefully according to World Anti-Doping Agency (WADA) guidelines in order to avoid enhanced performance. For instance the current WADA guidelines allow athletes to inhale up to 1600 μg salbutamol per day to avoid pharmaceutical induced performance enhancement [35,36]. The 2016 prohibited list includes all beta-2 agonists, including all optical isomers (e.g. d- and l-) except inhaled salbutamol (maximum 1600 μg over 24 hours), inhaled formoterol (maximum delivered dose 54 μg over 24 hours) and salmeterol in accordance with the manufacturers recommended therapeutic regimen [37]. It is still discussable if beta agonists can cause enhanced performance. Several studies show that even though that the lung function is enhanced the performance

Table 3: American Thoracic Society recommendations for EIB treatment and 2016 World Anti-Doping Agency (WADA) regulations.

Drug	Administration	Recommendation	Level of evidence	2016 World Anti-Doping Agency (WADA) regulations
SABA	Before exercise	Strong	High-quality	Inhaled salbutamol (maximum 1600 µg over 24 hours)
LABA	Recommended against daily use as single therapy	Strong	Moderate-quality	Inhaled formoterol (maximum delivered dose 54 µg over 24 hours) and salmeterol in accordance with the manufacturers recommended therapeutic regimen
ICS	Recommended daily administration	Strong	Moderate-quality	Prohibited in competition
	Recommended against administration only before exercise	Strong	Moderate-quality	
LRA	Recommended daily administration	Strong	Moderate-quality	Permitted
MCS	Before exercise	Strong	High-quality	Permitted
IAA	Before exercise	Weak	Low-quality	Permitted
AH	If symptoms persist despite using an inhaled SABA before exercise, or if the patient require an inhaled SABA daily or more frequently	Weak	Moderate-quality	Permitted
	Recommended against administration in patients who do not have allergies	Strong	Moderate-quality	Permitted

remains on the same level [38,39]. The inhalation of 1600 µg salbutamol improves FEV1 regardless of EVH status but does not improve 10-km time trial performance in male cyclists regardless of relative dose per kilogram of body weight or EVH status [40].

Finally several data show that supplementation with vitamins and fish oils can be helpful in controlling EIB symptoms [41-46].

A meta-analysis showed that vitamin C may decrease EIB proportion by 50%. Taking in considerations that vitamin C is safe and has low cost it seems reasonable for physically active people to test vitamin C when they have respiratory symptoms such as cough associated with exercise. Further research of vitamin C effects may give more detailed results [42].

In addition, a combination of warm-up with salbutamol prior to exercise results in substantial bronchodilation and thus a greater protective effect against developing EIB than either intervention alone [43]. Warm-up exercise before planned exercise is considered to be a strong recommendation with moderate level of evidence by the ATS [1].

Supplementation with fish oils showed positive results in several studies including randomized, double-blind, crossover study that also concluded its effectiveness as a monotherapy but still the current evidence is that no advantage exists in combination of montelukast and fish oil supplements [44-46]. Interestingly induced sputum differential cell count percentage and concentrations of LTC4-LTE4, PGD2, IL-1beta, and TNF-alpha were significantly reduced on the fish oil diet [46].

Finally recommendations such as the use of masks that warm and humidify the air during exercise for EIB patients who train in cold weather, low-salt diet, and dietary supplementation with fish oils and exclusion of dietary supplementation with lycopene are still controversial based in ATS guidelines [1].

Conclusion

Athletes are often considered to be an example of health but unfortunately it is not always true. EIB is a serious and frequently encountered condition among athletes and it requires careful medical attention from the healthcare provider. It is still unclear whether this condition affects athlete's performance but it should be monitored carefully in future. The management of this condition should be according to WADA's current standards.

References

1. Parsons JP, Hallstrand TS, Mastronarde JG, Kaminsky DA, Rundell KW, Hull JH, et al. An official American Thoracic Society clinical practice guideline: exercise-induced bronchoconstriction. Am J Respir Crit Care Med. 2013; 187: 1016-1027.
2. Weiler JM, Bonini S, Coifman R, Craig T, Delgado L, Capão-Filipe M, et al. American Academy of Allergy, Asthma & Immunology Work Group report: exercise-induced asthma. J Allergy Clin Immunol. 2007; 119: 1349-1358.
3. Ünal M, Sahinkaya T, Deniz Namaraslı, Akkaya V, Kayserilioglu A. The Prevalance of Exercise Induced Bronchoconstriction in Elite Athletes. Journal of Sports Science & Medicine. 2004; 3: 57-59.
4. Pohjantahti H, Laitinen J, Parkkari J. Exercise-induced bronchospasm among healthy elite cross country skiers and non-athletic students. Scand J Med Sci Sports. 2005; 15: 324-328.
5. Ogston J, Butcher JD. A sport-specific protocol for diagnosing exercise-induced asthma in cross-country skiers. Clin J Sport Med. 2002; 12: 291-295.
6. Sallaoui R, Chamari K, Mossa A, Tabka Z, Chtara M, Feki Y, et al. Exercise-induced bronchoconstriction and atopy in Tunisian athletes. BMC Pulmonary Medicine. 2009; 9: 8.
7. Stenfors N. Self-reported symptoms and bronchial hyperresponsiveness in elite cross-country skiers. Respir Med. 2010; 104: 1760-1763.
8. Helenius I, Haahtela T. Allergy and asthma in elite summer sport athletes. J Allergy Clin Immunol. 2000; 106: 444-452.
9. Anderson SD, Daviskas E. The mechanism of exercise-induced asthma is... J Allergy Clin Immunol. 2000; 106: 453-459.
10. Koh YI, Choi S. Blood eosinophil counts for the prediction of the severity of exercise-induced bronchospasm in asthma. Respir Med. 2002; 96: 120-125.
11. Bougault V, Turmel J, St-Laurent J, Bertrand M, Boulet LP. Asthma, airway inflammation and epithelial damage in swimmers and cold-air athletes. The European Respiratory Journal. 2009; 33: 740-746.
12. Sastre B, Fernandez-Nieto M, Rodriguez-Nieto MJ, Aguado E, Sastre J, del Pozo V. Distinctive bronchial inflammation status in athletes: basophils, a new player. European journal of applied physiology. 2013; 113: 703-711.
13. Sue-Chu M. Winter sports athletes: long-term effects of cold air exposure. Br J Sports Med. 2012; 46: 397-401.
14. Anderson SD, Kippelen P. Airway injury as a mechanism for exercise-induced bronchoconstriction in elite athletes. J Allergy Clin Immunol. 2008; 122: 225-235.

15. Bonini M, Gramiccioni C, Fioretti D, Ruckert B, Rinaldi M, Akdis C, et al. Asthma, allergy and the Olympics: a 12-year survey in elite athletes. Curr Opin Allergy Clin Immunol. 2015; 15: 184-192.

16. Nystad W, Harris J, Borgen JS. Asthma and wheezing among Norwegian elite athletes. Med Sci Sports Exerc. 2000; 32: 266-270.

17. Helenius I, Rytilä P, Sarna S, Lumme A, Helenius M, Remes V, et al. Effect of continuing or finishing high-level sports on airway inflammation, bronchial hyperresponsiveness, and asthma: a 5-year prospective follow-up study of 42 highly trained swimmers. J Allergy Clin Immunol. 2002; 109: 962-968.

18. [No authors listed]. Airway hyperresponsiveness and airway inflammation in elite swimmers. Clin Respir J. 2009; 3: 62.

19. Rundell KW, Anderson SD, Spiering BA, Judelson DA. Field exercise vs laboratory eucapnic voluntary hyperventilation to identify airway hyperresponsiveness in elite cold weather athletes. Chest. 2004; 125: 909-915.

20. Castricum A, Holzer K, Brukner P, Irving L. The role of the bronchial provocation challenge tests in the diagnosis of exercise-induced bronchoconstriction in elite swimmers. Br J Sports Med. 2010; 44: 736-740.

21. Holzer K, Anderson SD, Douglass J. Exercise in elite summer athletes: Challenges for diagnosis. J Allergy Clin Immunol. 2002; 110: 374-380.

22. Bougault V, Turmel J, Boulet LP. Bronchial challenges and respiratory symptoms in elite swimmers and winter sport athletes: Airway hyperresponsiveness in asthma: its measurement and clinical significance. Chest. 2010; 138: 31S-37S.

23. Bonini M, Palange P. Exercise-induced bronchoconstriction: new evidence in pathogenesis, diagnosis and treatment. Asthma Research and Practice. 2015; 1: 2.

24. Bougault V, Turmel J, Boulet LP. Bronchial challenges and respiratory symptoms in elite swimmers and winter sport athletes: Airway hyperresponsiveness in asthma: its measurement and clinical significance. Chest. 2010; 138: 09-1689.

25. Price OJ, Ansley L, Hull JH. Diagnosing exercise-induced bronchoconstriction with eucapnic voluntary hyperpnea: is one test enough? The journal of allergy and clinical immunology in practice. 2015; 3: 243-249.

26. Papaioannou AI, Bartziokas K, Loukides S, Papiris S, Kostikas K. Exercise Induced Bronchoconstriction: A clinical approach. Pneumon. 2014; 2.

27. Holzer K, Brukner P. Screening of athletes for exercise-induced bronchoconstriction. Clin J Sport Med. 2004; 14: 134-138.

28. Parsons JP, Cosmar D, Phillips G, Kaeding C, Best TM, Mastronarde JG. Screening for exercise-induced bronchoconstriction in college athletes. The Journal of asthma: official journal of the Association for the Care of Asthma. 2012; 49: 153-157.

29. Price OJ, Ansley L, Bikov A, Hull JH. The role of impulse oscillometry in detecting airway dysfunction in athletes. J Asthma. 2015 .

30. Dickinson J, McConnell A, Whyte G. Diagnosis of exercise-induced bronchoconstriction: eucapnic voluntary hyperpnoea challenges identify previously undiagnosed elite athletes with exercise-induced bronchoconstriction. Br J Sports Med. 2011; 45: 1126-1131.

31. Sallaoui R, Zendah I, Ghedira H, Belhaouz M, Ghrairi M, Amri M. Exercise-induced bronchoconstriction in Tunisian elite athletes is underdiagnosed. Open Access J Sports Med. 2011; 2: 41-46.

32. Helenius IJ, Tikkanen HO, Haahtela T. Occurrence of exercise induced bronchospasm in elite runners: dependence on atopy and exposure to cold air and pollen. Br J Sports Med. 1998; 32: 125-129.

33. Carlsen KH, Anderson SD, Bjermer L, Bonini S, Brusasco V, Canonica W, et al. Treatment of exercise-induced asthma, respiratory and allergic disorders in sports and the relationship to doping: Part II of the report from the Joint Task Force of European Respiratory Society (ERS) and European Academy of Allergy and Clinical Immunology (EAACI) in cooperation with GA(2)LEN. Allergy. 2008; 63: 492-505.

34. Philip G, Pearlman DS, Villarán C, Legrand C, Loeys T, Langdon RB, et al. Single-dose montelukast or salmeterol as protection against exercise-induced bronchoconstriction. Chest. 2007; 132: 875-883.

35. Dickinson J, Hu J, Chester N, Loosemore M, Whyte G. Acute impact of inhaled short acting b2-agonists on 5 km running performance. J Sports Sci Med. 2014; 13: 271-279.

36. Goubault C, Perault MC, Leleu E, Bouquet S, Legros P, Vandel B, et al. Effects of inhaled salbutamol in exercising non-asthmatic athletes. Thorax. 2001; 56: 675-679.

37. The World Anti-Doping Code. The revised 2014 Prohibited List.

38. Koch S, Karacabeyli D, Galts C, MacInnis MJ, Sporer BC, Koehle MS. Effects of inhaled bronchodilators on lung function and cycling performance in female athletes with and without exercise-induced bronchoconstriction. Journal of science and medicine in sport / Sports Medicine Australia. 2015; 18: 607-612.

39. Koch S, MacInnis MJ, Sporer BC, Rupert JL, Koehle MS. Inhaled salbutamol does not affect athletic performance in asthmatic and non-asthmatic cyclists. Br J Sports Med. 2015; 49: 51-55.

40. Koch S, Ahn JR, Koehle MS. High-Dose Inhaled Salbutamol Does Not Improve 10-km Cycling Time Trial Performance. Med Sci Sports Exerc. 2015; 47: 2373-2379.

41. Tecklenburg SL, Mickleborough TD, Fly AD, Bai Y, Stager JM. Ascorbic acid supplementation attenuates exercise-induced bronchoconstriction in patients with asthma. Respir Med. 2007; 101: 1770-1778.

42. Hemilä H. Vitamin C may alleviate exercise-induced bronchoconstriction: a meta-analysis. BMJ Open. 2013; 3.

43. Mickleborough TD, Lindley MR, Turner LA. Comparative effects of a high-intensity interval warm-up and salbutamol on the bronchoconstrictor response to exercise in asthmatic athletes. International journal of sports medicine. 2007; 28: 456-462.

44. Tecklenburg-Lund S, Mickleborough TD, Turner LA, Fly AD, Stager JM, Montgomery GS. Randomized controlled trial of fish oil and montelukast and their combination on airway inflammation and hyperpnea-induced bronchoconstriction. PloS one. 2010; 5: e13487.

45. Mickleborough TD, Murray RL, Ionescu AA, Lindley MR. Fish oil supplementation reduces severity of exercise-induced bronchoconstriction in elite athletes. Am J Respir Crit Care Med. 2003; 168: 1181-1189.

46. Mickleborough TD, Lindley MR, Ionescu AA, Fly AD. Protective effect of fish oil supplementation on exercise-induced bronchoconstriction in asthma. Chest. 2006; 129: 39-49.

Austin J Pulm Respir Med - Volume 3 Issue 1 - 2016
ISSN : 2381-9022 | www.austinpublishinggroup.com

Citation: Covantev S, Corlateanu A and Botnaru V. Exercise-Induced Bronchoconstriction in Athletes. Austin J Pulm Respir Med 2016; 3(1): 1037.