Prevalence and characteristics of asthma in the aquatic disciplines

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Background: Despite the health benefits of swimming as a form of exercise, evidence exists that both the swimming pool environment and endurance exercise are etiologic factors in the development of asthma. The prevalence of asthma in swimmers is high compared with that in participants in other Olympic sport disciplines. There are no publications comparing the prevalence of asthma in the 5 aquatic disciplines.
Objective: The purpose of this study is to examine and compare the prevalence of asthma in the aquatic disciplines and in contrast with other Olympic sports.
Methods: Therapeutic Use Exemptions containing objective evidence of athlete asthma/airway hyperresponsiveness (AHR) were collected for all aquatic athletes participating in swimming, diving, synchronized swimming, water polo, and open water swimming for major events during the time period from 2004-2009. The prevalence of asthma/AHR in the aquatic disciplines was analyzed for statistical significance (with 95% CIs) and also compared with that in other Olympic sports.
Results: Swimming had the highest prevalence of asthma/AHR in comparison with the other aquatic disciplines. The endurance aquatic disciplines have a higher prevalence of asthma/AHR than the aquatic nonendurance disciplines. Asthma/AHR is more common in Oceania, Europe, and North America than in Asia, Africa, and South America. In comparison with other Olympic sports, swimming, synchronized swimming, and open water swimming were among the top 5 sports for asthma/AHR prevalence.
Conclusion: Asthma/AHR in the endurance aquatic disciplines is common at the elite level and has a varied geographic distribution. Findings from this study demonstrate the need for development of aquatic discipline–specific prevention, screening, and treatment regimens. (J Allergy Clin Immunol 2015;■■■:■■■-■■■.)

Key words: *Asthma, exercise-induced bronchoconstriction, airway hyperresponsiveness, swimming, diving, synchronized swimming, water polo, Olympic Games, endurance training*

Swimming is a common form of exercise enjoyed around the world from the recreational to the elite level. Swimming is practiced by all age groups and has been prescribed as a recommended form of exercise for asthmatic patients for many years by respiratory and family physicians because swimming was thought to be less likely to trigger asthma symptoms[1] and is considered a safe and healthy activity.[2,3] However, evidence exists that implicates the aquatic environment itself as a cause of asthma/airway hyperresponsiveness (AHR) through exposure of the airways to irritants, such as pool chloramines.[4]

Asthma is diagnosed on clinical presentation of a constellation of recurrent symptoms, including cough, dyspnea, wheezing, chest tightness, and phlegm production. AHR is a feature of asthma in which the airways respond too much and too easily to stimuli.[5] Exercise-induced bronchoconstriction refers to the acute narrowing of the airway resulting from exercise. It often occurs in dry/cold sporting environments, such as ice-skating rink environments with poor air quality and chlorine-disinfected swimming pools. Exercised-induced bronchoconstriction can be of variable severity and can affect an athlete's performance in addition to his or her health.[5]

The presence of asthma in elite swimmers seems multifactorial. For the competitive swimmer, high ventilation rates and volumes during training are implicated in the development of asthma through airway remodeling caused by chronic inflammation, epithelial damage, or both.[6] Furthermore, exposure to the indoor aquatic environment might pose an increased risk of AHR through inhalation of chloramines, a byproduct of chlorine.[7-10] Inhaled chloramines are believed to induce disruption of the epithelial lining of the lung, promoting allergen

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Abbreviations used
AHR: Airway hyperresponsiveness
BPT: Bronchial provocation test
FINA: Federation Internationale de Natation
IBA: Inhaled β_2-agonist
IOC: International Olympic Committee
TUE: Therapeutic Use Exemption
WADA: World Anti-Doping Agency

sensitization.[11] Allergen exposure in sensitized subjects results in release of inflammatory mediators and sensitization of airway smooth muscle, leading to development of airway remodeling.[12] Airway remodeling can also be seen in swimmers without evidence of AHR and is thought to be the result of fibrogenesis induced by prolonged training in a chlorinated environment.[13]

The ventilatory demands of endurance sports require the athlete to breathe at a high flow for repeated prolonged periods of time over an extended athletic career. Such ventilatory rates and volumes result in cooling and dehydration of the airway mucosa, resulting in airway smooth muscle contraction.[14] Furthermore, hyperpnea-induced mechanical stress to the airways[15] might also constitute an insult to the epithelium and can lead to airway remodeling and subsequent changes in the contractile properties of bronchial smooth muscle.[16] In addition, during daily life or if training outdoors with a high ventilatory rate, the aquatic athlete can be exposed to other inhaled particulate matter, which can also negatively affect airway integrity.[17]

Because of variations in the requirements for elite performance between the aquatic disciplines, training regimens have evolved to be discipline specific, with significant differences in physiologic demands. These different types of training exposures might translate theoretically into differences in respiratory response to the training stimuli. Although there are many studies published on the diagnosis and treatment of asthma in swimmers,[6,13,18-26] to our knowledge, there are no publications studying asthma in the aquatic disciplines of synchronized swimming, open water swimming, and diving, and there is only one study on adolescent water polo players.[27] Understanding the health risks of the practice of aquatic sports is necessary to guide team physicians in their screening programs to optimize health and performance at the elite level, as well as the recreational level. Knowledge about the prevalence of asthma in the aquatic disciplines will be helpful in determining health promotion priorities for Federation Internationale de Natation (FINA).

It is hypothesized that asthma/AHR is common in elite swimming and in other endurance aquatic disciplines. In addition, it is hypothesized that aquatic sports will have a higher prevalence of asthma/AHR than other Olympic sports and that geographic variations in prevalence will be evident at the elite level. A unique large database containing objective evidence of asthma/AHR will be analyzed to confirm the hypotheses and to formulate recommendations for future research. Therefore the purpose of this study was (1) to assess the overall prevalence of asthma/AHR in aquatic sports, (2) to assess differences in the prevalence in asthma/AHR between the aquatic disciplines, (3) to compare the prevalence of aquatic asthma/AHR by geographic continent, (4) to compare the overall prevalence of asthma/AHR between aquatic and nonaquatic athletes at the Olympic Games, and (5) to compare the prevalence of endurance versus nonendurance sport disciplines.

METHODS

Determination of the study period

We studied historical data derived from Therapeutic Use Exemptions (TUEs) containing the objective diagnoses of AHR of all competing aquatic athletes at the 2005, 2007, and 2009 FINA World Championships and the 2004 and 2008 Olympic Games. Commencing in 2002, the International Olympic Committee (IOC) instituted legislation requiring all athletes competing at the Olympic Games and using inhaled β_2-agonists to provide objective proof of AHR.[28,29] In 2004, all inhaled β_2-agonists, including salbutamol, salmeterol, formoterol, and terbutaline, were placed on the World Anti-Doping Agency (WADA) Prohibited List requiring pre-event medical demonstration of asthma/AHR to approve a TUE. Objective tests to establish a diagnosis of asthma/AHR included demonstration of reversible airway obstruction obtained based on a bronchodilator response (significant increase in FEV_1), a positive bronchial provocation test (BPT) response, or both (Table I).[30] In 2010, the WADA removed the requirement for a TUE for salbutamol and salmeterol because urinary threshold levels for therapeutic use were established.[31] Consequently, for the major aquatic competition events during the time period of 2004-2009, TUEs for AHR are available for all participating athletes.

Definition of asthma

We considered that an athlete had asthma/AHR if he or she had an objective demonstration of airway obstruction based on spirometric or BPT result, as outlined in Table I.

Acquisition and processing of nominator and denominator data

TUEs were obtained for the Olympic Games in 2004 and 2008 through the Chairman of the IOC TUE Committee (KF). The TUEs for the 2005, 2007, and 2009 FINA World Championships were obtained from the FINA anti-doping archives. There was no major international aquatic competitive event in 2006. The Olympic TUE data were processed to isolate the TUEs for each of the aquatic disciplines of swimming, synchronized swimming, diving, water polo, and open water swimming. All TUEs from the Olympic database and the FINA database were checked against the event participation database[32,33] to confirm that the athlete with the granted TUE actually competed in the respective competitive event. TUEs for athletes who did not compete during the target competitive event were removed from the database.

TUEs granted by FINA had a duration of 4 years. As such, athlete participation in major competitive events was confirmed for the 4 years after the granting date of the TUE. For example, if an athlete was granted a TUE for asthma/AHR in 2005 and competed in 2007 and 2008, the athlete was added to the database for the subsequent years to be counted in prevalence analysis. TUEs granted by the IOC were valid for 4 years and were also considered valid for the subsequent Olympic Games. Therefore athletes with TUEs granted by the IOC in 2004 were reviewed for participation in subsequent FINA World Championships (2005 and 2007) and for participation in the 2008 Olympic Games. Athletes with TUEs granted by the IOC in 2008 were reviewed for participation in the FINA World Championships in 2009. Those athletes competing in subsequent events with a valid TUE were added to the respective database for prevalence calculations. Prevalence was defined as the proportion of athletes at the target event competing with a TUE for asthma/AHR.

The total number of competing aquatic athletes in the FINA events was determined from the respective discipline-specific results page of the Omega Web site.[32] The total number of competing aquatic athletes for each discipline in the Olympic Games was obtained from the Olympic Web site.[33]

The prevalence of asthma by geographic region for each major event was assessed. All participating athletes' countries of origin were obtained from the official results database for the aquatic disciplines for each target event.[32,33]