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Allergic Rhinitis and Sports

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1. Introduction

Rhinitis is an inflammation of the mucosal lining of the nose and is characterized by one or more of the following symptoms: nasal congestion, anterior and posterior rhinorrhea, sneezing, and itching (Bousquet, Khaltaev et al. 2008; Wallace, Dykewicz et al. 2008). It can be associated with eye symptoms (rhinoconjuntivitis) and ear or throat complains (Bousquet, Khaltaev et al. 2008). Rhinitis can be classified etiologically in two types: Allergic Rhinitis (AR) and Nonallergic Rhinitis (Table1) (Bousquet, Khaltaev et al. 2008; Wallace, Dykewicz et al. 2008).

The most common type is AR, and its prevalence has increased over the last decades (Bousquet, Khaltaev et al. 2008). Associated risk factors, such as atopy, family history of allergy, and exposure to allergens and pollution, might explain this fact (Bousquet, Khaltaev et al. 2008; Scadding, Durham et al. 2008). AR is a multifactorial disease influenced by genetic and environmental interaction (Davila, Mullol et al. 2009). Despite that 30-50% of rhinitis patients have non-allergic triggers, 44 to 87% might have a combination of allergic and non-allergic rhinitis mechanism (Dykewicz and Hamilos 2010).

Allergic inflammation is the basic mechanism of this disease, and classically is considered to result from an IgE mediated reaction (Bousquet, Khaltaev et al. 2008). Allergic response can be biphasic, mediated by an early and a late phase (Durham 1998). Early phase response, occurs within the first 0-60 min following allergen exposure, and is mediated by mast cell degranulation and mediator release (Durham 1998; Bousquet, Khaltaev et al. 2008; Scadding, Durham et al. 2008). The late phase reaction involves inflammation, mediated by recruitment of several inflammatory cells, specifically Th2 mediated cell response (Durham 1998). Clinically, AR appears as nasal sneezing, itching of the nose, rhinorrhoea and nasal blockage, in the first minutes after allergen contact. Symptoms like chronic obstruction, hyposmia, post-nasal mucous discharge and nasal hyper-reactivity occur in the late-phase response (Scadding, Durham et al. 2008; Lim and Leong 2010).

World Health Organization (WHO) through the working group Allergic Rhinitis Impact on Asthma (ARIA), changed the classification from time of exposure point of view (*seasonal, perennial and occupational*) to a symptomatic definition (*intermittent allergic rhinitis and persistent allergic rhinitis*) and severity characterization *(mild or moderate-severe)*. The seasonal and perennial rhinitis classification is still useful for diagnosis and immunotherapy treatment decision and can be used alongside with ARIA classification (Bousquet, Khaltaev et al. 2008).

I- Allergic rhinitis
II- Nonallergic rhinitis
A.Vasomotor rhinitis (triggered by irritant, cold air, exercise, undeterminated trigger)
B. Gustatory rhinitis
C. Infectious rhinitis
III- Occupational rhinitis
A. IgE mediated (protein or chemical allergens)
B. Uncertain immune mechanism (chemical respiratory sensitizers)
C. Work agravated rhinitis
IV- Rhinitis syndromes
A. Hormonal induced (pregnancy or menstrual cicle induced)
B. Drug induced
1. Rhinitis *medicamentosa*
2. Nonsteroidal anti-inflammatory drugs
3. Oral contraceptives
4. Antihypertensive and cardiovascular agents
C. Atrophic rhinitis
D. Rhinitis associated with inflammatory-immunologic disorders
1. Granulomatous infection
2. Wegener granulomatous
3. Sarcoidosis
4. Midline granuloma
5. Churgh-Strauss syndrome
6. Relapsing polychondritis
7. Amyloidosis

Table 1. Rhinitis classification (adapted from *Dykewicz and Hamilos 2010*)

The most frequent allergic triggers are inhalant allergens, namely mites, pollens, animals and fungi. According to different triggers they can cause perennial or seasonal symptoms. Pre-existing rhinitis can be aggravated by work-place irritants like smoke, cold air and pollutants (Scadding, Durham et al. 2008).

Rhinitis has debilitating consequences, significantly interfering with patients quality of life and activity, namely in sports practice (Katelaris, Carrozzi et al. 2003). It has negative impact on cognitive functions, school performance, sleep, quality of life and even in behaviour, which can significantly impair athletics performance (Katelaris, Carrozzi et al. 2003). This is particularly important, as a higher prevalence of rhinitis has been reported in athletes than general population (Delgado, Moreira et al. 2006). Excluding exercise-induced rhinitis, idiopathic rhinitis and nasal symptoms related to physical, cold air, and chemical contact factors, allergic rhinitis can account for prevalences up to 30% in an athlete population. This chapter deals with allergic rhinitis in sports.

2. Allergic rhinitis in athletes

Exercise induces modulation in innate and adaptive immune system, dependent on host defence, activity level and disease susceptibility (Walsh, Gleeson et al. 2011). This might explain why in some cases there seems to be a possible susceptibility of elite athletes to infection, namely in the upper respiratory tract infection (Moreira 2009; Dijkstra and

Robson-Ansley 2011). In a recent position statement regarding immune function and exercise, *Walsh and colleagues* (Walsh, Gleeson et al. 2011) proposed that in young healthy subjects, who already possess excellent immune responses, an increase in physical activity might not be beneficial to the immune system response, and might induce immune-disease susceptibility, like auto-immune disease or allergy. In fact, self-reported episodes of infection may not be related with infection *per se*, but with allergy-related symptoms (Dijkstra and Robson-Ansley 2011). On other side, the positive effects of exercise training on immune function are more frequently seen when immune function is sub-optimal like in elderly people (Walsh, Gleeson et al. 2011).

There is also immunological data that exercise training can lead to a polarization of T-helper lymphocytes toward the Th2 phenotype, which is known to mediate allergic response (Dijkstra and Robson-Ansley 2011). Athletes and people who regularly exercise in the outdoor urban environment are a specific population in risk for allergic rhinitis (Delgado, Moreira et al. 2006). There is evidence indicating an increased incidence of exercise-induce bronchospasm and atopy in highly trained athletes compared with nonathletic controls (Carlsen, Anderson et al. 2008).

2.1 Nasal physiology and pathophysiology

The upper airways, that include nasal cavity and its tissues, lie in a bony structure that, unlike the lower airways structure, cannot change shape (Dahl and Mygind 1998). Upper airways comprise an epithelium with a basement membrane and a submucosal layer, which is full of venous sinusoids (Dahl and Mygind 1998). These vessels and mucosa glands are responsible for filtration, humidification and warming of inhaled air before it reaches the lower respiratory tract. They are regulated by autonomic nervous system reflexes (Delgado, Moreira et al. 2006) and swelling of the venous sinusoids can lead to upper airway obstruction (Dahl and Mygind 1998). Activation of local nerve reflexes causes sneezing, watery discharge and vasodilation, symptoms associated with rhinitis(Dahl and Mygind 1998).

During exercise, autonomic reflexes improve nasal efficiency (Bonini, Bonini et al. 2006). In dynamic exercise training due to an increase of nasal sympathetic activity, venous sinusoids constrict. The same does not happen with isometric exercise types (Dahl and Mygind 1998; Bonini, Bonini et al. 2006). A watery discharge can also be produced, because cold air induces glandular hyper secretion (Dahl and Mygind 1998; Bonini, Bonini et al. 2006).

During training athletes are repeatedly exposed to several risk factors (allergens, cold air and pollutants) increasing rhinitis symptoms in susceptible individuals (Delgado, Moreira et al. 2006). Some experience improvement with exercise, mediated by nasal sympathetic tone, others may have their symptoms worsen (Valero, Serrano et al. 2005). In fact, weather conditions, like cold or dry air, inhalation of irritants in outdoor exercise exposure can explain the worsening symptoms in some athletes (Schwartz, Delgado et al. 2008). In swimmers chlorine inhalation (an irritant) induces nasal congestion in a more pronounced way in subjects with allergic rhinitis than in nonrhinitic. Some authors explained this fact by nasal mucosa damage mediated by chlorinated products, which could facilitate the penetration of aeroallergens increasing the risk of allergic manifestation (Shusterman, Murphy et al. 1998; Shusterman, Balmes et al. 2003; Shusterman, Murphy et al. 2003). This hypothesis was not supported by a more recent study showing that swimmers had worse rhinitis symptoms, but independently of their atopic status (Alves, Martins et al. 2010).

2.2 Epidemiology

Allergic rhinitis affects 10-20% of general population, and in a higher percentage elite competitive athletes (Katelaris, Carrozzi et al. 2006; Bousquet, Khaltaev et al. 2008). A study in 291 German athletes found a significative increased prevalence of hay fever (25% versus 17% in general population), with the highest prevalence in endurance athletes (Thomas, Wolfarth et al. 2010). These data are concordant with previous data, namely a Canadian study of 698 athletes who practiced different sports under antagonist conditions (dry, cold, humid or mixed air conditions) - a 21% prevalence of allergic rhinitis was found in all participants, except in subjects training in dry air conditions (17%) (Langdeau, Turcotte et al. 2004). In 162 Finish swimmers, 29% had a positive skin test reaction to pollen associated with rhinoconjunctivitis symptoms during spring or summer (Helenius and Haahtela 2000). During the 1990`s, several epidemiological studies of athletes in different sports were made using larger samples. Two studies with 2060 (Helbling, Jenoure et al. 1990) and 1530 Swiss athletes (Kaelin and Brandli 1993) showed a prevalence of rhinoconjunctivitis of respectively 16,8 and 19,7%. In several studies published in the last two decades a prevalence range between 13.3-48.6% was found (Delgado, Moreira et al. 2006) Table 2.

Reference	Design and methods	Year of study, subjects (n)	Rhinitis/SARC* Prevalence (%)
Fitch KD, J Allergy Clin Immunol 1984;73:72-7	Retrospective; medical records analysis	1976, Australian Olympics (185)	8.6
		1980, Australian Olympics (106)	7.5
Helbling A, Schweiz Med Wochenschr 1990;120(7):231-6	Cross-sectional; questionnaire	1986, Swiss athletes (2,060)	16.8*
Kaelin M, Schweiz Med Wochenschr 1993; 123(5): 174-82	Cross-sectional; questionnaire	1990, Swiss athletes (1530)	19.7%*
Potts J, Sports Med 1996; 21:256–261	Cross-sectional; questionnaire	1995, Canadian swimmers (738)	19.0*
Helenius I, J Allergy Clin Immunol 1998; 101(5):646-52	Cross-sectional; skin prick tests with medical diagnosis	1996, Finnish summer athletes (162)	29.6*
Weiler J, J Allergy Clin Immunol 1998; 102:722-6	Cross-sectional, questionnaire (USOC-MHQ)	1996, US summer Olympics (699)	16.9
Weiler J, J Allergy Clin Immunol 2000; 106:267-1	Cross-sectional, questionnaire (USOC-MHQ)	1998, US winter Olympics (699)	13.3
Katelaris CH, J Allergy Clin Immunol 2000; 106:260-6	Cross-sectional; skin prick tests with medical diagnosis	1997/8, Australian summer Olympics (214)	41.0/29.0*
Katelaris CH, Clin J Sport Med 2006; 16(5):401-5	Cross-sectional; skin prick tests with medical diagnosis	1999, Australian Olympics/Paralympics (977)	37.0/24.0*

Lapucci G, J Allergy Clin Immunol 2003; 111:S142	Cross-sectional; skin prick tests with medical diagnosis	2000, Italian summer Olympics (265)	25.3*
Bonadonna P, Am J Rhinol. 2001; 15(5):297-301.	Cross-sectional, questionnaire on cold-induced rhinitis	2001, Italian skiers (144)	48.6
Alaranta A, Med Sci Sports Exerc 2005 ; 37, 5, 707–11	Cross-sectional; self reported medical diagnosis	2002, Finnish Olympic athletes (446);	26.5
		Subgroup of endurance athletes (108)	36.1
Randolph C. Med Sci Sport Exerc 2006:2053–7	Cross-sectional; questionnaire (USOC-MHQ)	2003/4, US recreational runners (484)	34.7
Moreira A. Respir Med 2007;101(6):1123–31	Cross-sectional; self reported medical diagnosis	2003, Finnish marathon runners (141)	17.3
Bonini M, Allergy 2007: 62: 1166-70	Cross-sectional; medical diagnosis	2006, Italian preOlympics (98)	34.7
Macucci F, J Sports Med Phys Fitness. 2007 ; 47(3):351-5	Cross-sectional; medical diagnosis	2006, Italian young athletes (352)	22.2
Salonen RO, Environ Int. 2008; 34(1):51-7	Cross-sectional; self reported medical diagnosis	2007, Finnish young hockey players (793)	18.3
Thomas S; Allergy Asthma Clin Immunol. 2010 Nov 30;6(1):31.	Cross-sectional; questionnaire	2008, German athletes candidates for Summer Olympic Games (291)	25*

Table 2. Prevalence (%) of rhinitis or seasonal allergic rhinoconjunctivitis (SARC) in athletes adapted and updated from *Schwartz, Delgado et al. 2008*..

Allergic rhinitis and asthma frequently co-exist and it seems to be a higher prevalence of asthma in athletes than in the general population (Thomas, Wolfarth et al. 2010). The prevalence of asthma in both the Summer and Winter Olympic athletes has been progressively increasing over recent years (Li, Lu et al. 2008). The prevalence of asthma reported in elite athletes ranged between 3.7-22.8% depending on athletes population (Bonini, Bonini et al. 2006). An evidence-based review of Joint Task Force of the European Respiratory Society (ERS) and the European Academy of Allergy and Clinical Immunology (EAACI) in cooperation with GA2LEN concluded that top athletes are at increased risk of asthma and bronchial hyperactivity, especially with endurance sports practice (Carlsen, Anderson et al. 2008).

The allergic response causes nasal and conjunctival congestion, tearing, breathing difficulties, pruritus, fatigue, and mood changes, which might affect athletic performance (Komarow and Postolache 2005). *Kateralis* showed over spring season a negative effect of allergic rhinoconjuntivitis on performance scores (ability to train and compete). Also a resolution of those symptoms, namely eye symptoms, and improvement on quality of life and performance scores, was seen after treatment with intranasal corticosteroids (Katelaris, Carrozzi et al. 2002).

2.3 Risk factors and exposure

During exercise ventilation increases in power athletes for a short period of time and for longer periods in resistance athletes (Bonini, Bonini et al. 2006). Most of this exercise is practiced in outdoor environments; therefore, athletes are strongly and repeatedly exposed to large amounts of aeroallergens and pollutants, including smoke. This contact in training or in competition periods may increase the likelihood of exercise-induced respiratory symptoms (Delgado, Moreira et al. 2006). The climate conditions, namely the inhaled air temperature and humidity also affect these patients. In swimmers it is also important to consider the contact with chlorine derivatives (Bonini, Bonini et al. 2006; Alves, Martins et al. 2010).

2.3.1 Allergens

Athletes involved in outdoor sports frequently exercise during or just after peak allergen seasons. In fact, major sports events frequently occur at the end of spring and beginning of the summer, and in urban settings (Delgado, Moreira et al. 2006). The Sydney Olympic Games were the second games in the last century to be held in springtime (Katelaris, Carrozzi et al. 2006). Kateralis monitored the pollen levels at Olympic Sydney facilities, and performed a study on Australian elite athletes in order to ascertain the prevalence of allergic conjunctivitis, sensitization and quality of life effect. They found that 41% had allergic rhinoconjunctivitis and, in those with pollen allergy (29%), a significant increase in nasal symptoms with a decreased quality of life score were found (Katelaris, Carrozzi et al. 2000). Aquatic sports athletes were more prone to be symptomatic.

Aerobiological records of pollens are frequently used to monitor the pollen levels and it is important for athletes to prepare themselves, particularly if they are symptomatic to some allergen. An example was the set up of an aerobiological network for the Athens summer Olympic Games (Gioulekas, Damialis et al. 2003).

Indoor allergens, namely mites, are not usually studied, due to the decreased frequency of contact and the specific association of more severe symptoms with endurance outdoor exercise. However, in some more indoor sports persistent rhinitis symptoms can occur and it may be relevant to control this environmental exposure in order to achieve the highest performance levels.

2.3.2 Air pollution

Urban type pollution, automobile and factory exhausts, tobacco smoking and occupational exposures are of great concern globally. Pollutants seem to interact with allergens in inducing sensitization and triggering symptoms in allergic patients (Bonini, Bonini et al. 2006). Increased reactivity to irritants is a phenotypic characteristic of both allergic and non-allergic rhinitis (Bousquet, Khaltaev et al. 2008). There are several studies pointing to adverse effects of outdoor air pollution, caused by carbon monoxide, nitric oxide and ozone among others (Delgado, Moreira et al. 2006). The two agents that most frequently affect upper respiratory airways and rhinitis are: particulate matter, namely diesel exhaust particles (DEP), which result from incomplete combustion of fuels and lubricants (Bousquet, Khaltaev et al. 2008) and volatile organic compounds, whose secondary pollutant is ozone formed through sun-light dependent reaction of volatile compounds. Their peak production is from April to September in the Northern Hemisphere, and a large percentage (40%) is completely absorbed by nasal mucosa (Bousquet, Khaltaev et al. 2008). They enhance the

production of oxygen's derivatives, increasing the permeability of epithelial cells (Bonay and Aubier 2007). Ozone increases the late-phase response to nasal allergens, increasing the eosinophilic influx after exposure and, in nasal mucosa, the histamine containing and inflammatory cells are increased in number (Delgado, Moreira et al. 2006).
In several studies it has been shown that patients living in traffic congested areas have more severe rhinitis and conjunctivitis symptoms (D'Amato and Cecchi 2008). A recently published study in Beijing, using questionnaires in 31,829 individuals and monitoring PM10, SO2 and NO2 air levels, found a significant association between outpatient visits for allergic rhinitis and increasing air pollutant levels (Zhang, Wang et al. 2011). DEP have pro-allergic effects and, associated with pollen exposure, might induce an allergic breakthrough in atopic patients and increase allergic reactions in already symptomatic ones (Delgado, Moreira et al. 2006; Lubitz, Schober et al. 2010). This finding is particularly relevant in athletes who train or compete in outdoor urban environments. So, at the Olympic Games in China, besides allergen monitoring air quality was also monitored to certify air quality, in order athletes could perform their sports safely (Li, Lu et al. 2008). In fact, elite athletes practice sport around the world under different conditions and should be informed to what environment exposure they will be submitted, to adapt themselves and have appropriate preventive measures, namely their allergic symptoms fully controlled.
Besides nasal symptoms, lower airway pathways can also be severely affected, with increasing bronchial hyperactivity and asthma (Bonay and Aubier 2007).
Tobacco smoke is not advised in all populations, and especially in sports practice. Despite this, some athletes smoke or are exposed to passive smoke. Nasal symptoms, rhinorrea and nasal obstruction can occur under tobacco exposure, but not always these are consistent with increased total and specific IgEs (Bousquet, Khaltaev et al. 2008).

2.3.3 Climate exposure

The exposure to different environmental conditions, that are specific to a particular sport, definitely contribute to rhinitis symptoms. Rhinorhea and nasal congestion after exposure to cold air, known as "skier´s nose", can occur in normal individuals, through parasympathetic reflex. This mechanism of rhinitis is not associated with a particular allergic aetiology. In fact, cold dry air is frequently used for determining the presence and degree of nasal hyperreactivity in nonallergic non-infectious perennial rhinitis (Braat, Mulder et al. 1998). In high performance athletes, namely skiers, long distance runners and swimmers with long term exposure to cold, the repeated cooling and drying of mucosa results in an inflammatory infiltration of the airway mucosa, and these effects are reversed after stopping the high performance exercise (Koskela 2007).
In runners, an initial decongestion of mucosa occurs and it is maintained nearly 30 minutes after stopping exercise. This reduction of nasal resistance can lead to mucosa dehydration and a rebound increase in nasal secretion to compensate it. This "runner`s nose" is also integrated in differential diagnosis of allergic rhinitis (Bonini, Bonini et al. 2006). Swimmers are also a specific population of athletes. Their long term and high exposure to chlorine derivatives during regular trainings and competition at increased ventilation can induce mucosal inflammation which facilitate the responsiveness to airborne allergens and induces bronchial hyper responsiveness. *Kateralis* found confirming data in a group of swimmers that were more likely to have rhinitis symptoms and allergic sensitization than those active

in other sports (Katelaris, Carrozzi et al. 2000). In a recent study evaluating the nasal response to exercise in competitive swimmers compared with runners, although swimmers experienced worsening of nasal function after training, these data were independent of the atopic status of the athlete (Alves, Martins et al. 2010), which imposes the question of the swimmers environment as a risk factor for rhinitis.

2.3.4 Infections

Upper respiratory infections, namely acute viral rhinosinusitis, are extremely common in general population. It seems that athletes have an increased incidence, although a comprehensive explanation of this phenomenon was not yet found (Moreira 2009). A recent position statement questions the infectious aetiology of these respiratory symptoms, as few of them had no infectious agent identified. So these symptoms might be due only to an increased inflammation state (Walsh, Gleeson et al. 2011).

2.4 Effects of allergic rhinitis on exercise performance

Allergic rhinoconjunctivitis may be associated with a significant morbidity and a negative impact on life quality. In the general population, cognitive functions, school performance, sleep and even behavioural effects were described, namely in children with attention-deficit hyperreactivity disorders (Borres 2009). In a questionnaire of quality of life performed at spring-time, *Kateralis* showed poorer results in the allergic group, although the sample number was small (18 athletes) (Katelaris, Carrozzi et al. 2003). In another study with a larger sample, 145 athletes with allergic rhinitis who agreed to be treated, had a significant improvement of their quality of life scores under budesonide therapy (Katelaris, Carrozzi et al. 2002). Until now it was not possible to confirm the association of poorly treated rhinitis and a bad exercise performance (Dijkstra and Robson-Ansley 2011). It seems probable that altered airflow dynamics and ventilation caused by allergic rhinitis and nasal obstruction can potentially have a negative effect, mainly in high-intensity activities (Dijkstra and Robson-Ansley 2011). Any factors affecting sleep, decreasing the ability to concentrate or reducing physical fitness, have an easy understandable impact on sports performance. So, despite a direct association has not been proven yet, an indirect one is easily extrapolated (Dijkstra and Robson-Ansley 2011).

The cognitive impact (learning ability and memory) of rhinitis has been particularly studied in children and it seems that patients on anti-histaminic therapy have worse outcomes than patients on placebo (Borres 2009). In a recent study, children with allergic rhinitis on second generation anti-histaminic drugs had a greater treatment satisfaction (Ferrer, Morais-Almeida et al. 2010). Learning disability is a consequence of the frequent sleep disturbances, resulting in daytime sleepiness. Impaired sleep is secondary to nasal congestion which causes micro-arousal and irregular breathing, with snoring and apnea. A secondary effect of all this is school and work absenteeism and training capacity disability (Borres 2009). Correct diagnosis and management of allergic rhinitis can reduce the disease impact.

2.5 Diagnosis

Diagnosis of allergic rhinitis in athletes is based in the concordance of a suggestive history of allergic symptoms and physical examination, supported by diagnostic tests. (Bousquet, Khaltaev et al. 2008; Scadding, Hellings et al. 2011).

2.5.1 History and physical examination

A thorough allergic history remains the best diagnostic tool available (Wallace, Dykewicz et al. 2008; Scadding, Hellings et al. 2011). It is essential for an accurate diagnosis of rhinitis and for assessment of its severity and treatment response (Bousquet, Khaltaev et al. 2008). The patient, in this case the athlete, may present with a variety of symptoms and signs associated with allergic rhinitis such as sneezing, anterior rhinorrhoea and bilateral nasal obstruction (Dijkstra and Robson-Ansley 2011). Frequently, ocular symptoms are concomitant with tearing, burning and itching. Other symptoms include significant loss of smell (hyposmia or anosmia), snoring, post nasal drip or chronic cough, itching ears, nose and throat (Bousquet, Khaltaev et al. 2008; Dijkstra and Robson-Ansley 2011). In athletes, clinical presentation is frequently more subtle and might include poor-quality sleep, fatigue, reduced exercise performance and difficulty to recover after more demanding exercise sessions (Dijkstra and Robson-Ansley 2011). An effective evaluation should include symptoms characterization pattern, chronicity, seasonality and triggers of nasal and related symptoms, medications response, presence of coexisting conditions and the relation with training practice. It is also very important to include assessment of quality of life (Wallace, Dykewicz et al. 2008).

Physical examination of all organ systems potentially affected by allergies should be performed. Further attention should be given for upper respiratory tract system, namely nasal and oropharyngeal examination. Usually in patients with mild intermittent allergic rhinitis, a nasal examination is normal. In other patients, the nasal examination can show bluish-grey discoloration and edema or erythema of mucosa with clear watery rhinorrhoea (Scadding, Hellings et al. 2011). Infectious complications of rhinitis to which athletes seem to be more prone, like otitis and sinusitis, should be discarded during this examination (Lim and Leong 2010). It is important to explore, during clinical investigations, the differential diagnosis for similar symptoms, like non-allergic ones.

2.5.2 Investigations

In an athlete with persistent symptoms or when an allergic aetiology for upper respiratory symptoms is suspected, skin prick testing (SPT) with standardized allergens and/or measurement of allergen-specific IgE in serum should be used. Further investigation of other allergic diseases, namely asthma or exercise-induced bronchospasm should be considered and studied accordingly (Carlsen, Anderson et al. 2008).

Skin prick tests are relevant markers of the IgE-mediated allergic reaction (Bousquet, Khaltaev et al. 2008; Scadding, Durham et al. 2008). They should be carried out in all cases of suspected allergic rhinitis (Scadding, Durham et al. 2008) because there is a high degree of correlation between symptoms and provocative challenges (Bousquet, Khaltaev et al. 2008). The skin reaction is, however, dependent on several variables, namely the quality of the allergen extracts, age, seasonal variation of the sensitization, medications, and even the test interpretation can vary between individuals (Bousquet, Khaltaev et al. 2008; Scadding, Hellings et al. 2011). False positives mostly occur due to dermographism or irritant substances and false negatives are secondary to poor potency extracts, suppressed skin reaction due to antihistamines, tricyclic antidepressants or topical steroids, or an improper technique (Bousquet, Khaltaev et al. 2008; Scadding, Durham et al. 2008).

Using a radioimmunoassay or enzyme immunoassay it is possible to measure serum-total IgE and serum-specific IgE. These can be requested when skin tests are not possible, such as

patients under therapy suppressing skin reactivity or when SPT in association with the clinical exam are not concordant (Bousquet, Khaltaev et al. 2008; Scadding, Durham et al. 2008; Wallace, Dykewicz et al. 2008). An isolated total IgE measurement alone should not be used for screening allergic diseases, but may aid the interpretation of specific IgE tests (Bousquet, Khaltaev et al. 2008; Scadding, Durham et al. 2008). The sensitivity of serum specific IgE measurements compared with SPT can vary with the immunoassay technique used (Wallace, Dykewicz et al. 2008). Other *in vitro* tests used are peripheral blood activation markers, through the evaluation of blood basophiles response of degranulation and mediators release (histamine, CysTL, CD63/ CD203c expression) after stimulation with specific allergens. These tests are still just used for investigation (Bousquet, Khaltaev et al. 2008).

Nasal challenge tests are not necessary to confirm diagnosis. They are usually used for research. (Bousquet, Khaltaev et al. 2008; Scadding, Durham et al. 2008)

Imaging of the nose and sino-nasal cavity is used to differentiate the source of sino-nasal symptoms, relation of sino-nasal problem with surrounding structures and the extent of the disease (Scadding, Hellings et al. 2011). Plain sinus radiographs are not indicated in allergic rhinitis or rhinosinusitis diagnosis (Bousquet, Khaltaev et al. 2008). Computerized tomography scan is actually the main radiological investigation for sino-nasal disorders. It is indicated for differential diagnosis purposes, to exclude chronic rhinosinusitis, eliminate rhinitis complication and to evaluate non-responders to treatment (Bousquet, Khaltaev et al. 2008; Scadding, Hellings et al. 2011). It can be particularly useful in athletes to exclude traumatic lesions, which occur frequently in close-contact sports, like box or soccer. It can also be used for monitoring allergic rhinitis disease complications. Magnetic resonance imaging is rarely indicated.

2.5.3 Evaluation tests for severity and allergic rhinitis control

To evaluate severity in an objective way measurements of nasal obstruction and smell are used (Bousquet, Khaltaev et al. 2008). These tests are not made in routine clinical practice but can be useful when allergen challenges are undertaken or septal surgery is contemplated (Scadding, Durham et al. 2008).

Nasal patency can be monitored objectively using nasal peak inspiratory and expiratory flow, acoustic rhinometry, that measures the nasal cavity volume, and rhinomanometry that measures nasal airflow and pressure (Scadding, Hellings et al. 2011). In clinical practice the most frequently used is peak nasal inspiratory flow because it is simple, cheap, fast, available and it can be used for disease home monitoring (Wallace, Dykewicz et al. 2008). Olfactory tests are subjective test that measure odour threshold, discrimination and identification (Bousquet, Khaltaev et al. 2008; Scadding, Durham et al. 2008).

Nasal nitric oxide measurement may be a useful tool in diagnosis, management and to alert for possible mucociliary defects, but its utility in allergic rhinitis needs to be further evaluated (Bousquet, Khaltaev et al. 2008; Scadding, Hellings et al. 2011).

Rhinitis control is frequently monitored with control questionnaires and visual analogue scales (Bousquet, Khaltaev et al. 2008). There are several questionnaires, and some are being proposed for validation, but none is specific for the athletic population. The Rhinitis Control Assessment Test, a 6-item patient completed instrument, and Control of Allergic Rhinitis and Asthma Test (CARAT), which uses 10 questions, are such examples (Fonseca, Nogueira-Silva et al. 2010; Schatz, Meltzer et al. 2010). Specific questionnaires for athletes are also

available, such the Allergy Questionnaire for Atheletes (AQUA) that was developed by Bonini, adapting the European Community Respiratory Health Survey Questionnaire (Bonini, Braido et al. 2009).

2.6 Management allergic rhinitis in athletes

Management of allergic rhinitis encompasses patient education, environmental control, pharmacotherapy and allergen-specific immunotherapy. Surgical options may be used in highly selected cases (Bousquet, Khaltaev et al. 2008). Appropriate management requires an "evidence-based medicine" approach, as it is recommended on 2008 and 2010 guidelines of Allergic Rhinitis and its Impact on Asthma (ARIA)(Bousquet, Khaltaev et al. 2008; Brozek, Bousquet et al. 2010). For the elite athlete, it is also important to minimise the potential detrimental effects of allergic symptoms and treatment on performance (Katelaris, Carrozzi et al. 2003).

Treatment requires careful planning to comply to the "anti-doping" regulations and avoid detrimental influences of treatment adverse effects (Katelaris, Carrozzi et al. 2003). Specific aims for the athlete population are outlined in table 3.

Management Plan
Early recognition and diagnosis to avoid exposure to peak levels of relevant allergens and pollutants
Reduction of symptoms and improvement of nasal function to minimize negative effects on sport performance and the risk of exercise-induced asthma
Use therapies complying with World Anti-Doping Agency, not affecting athletic performance

Table 3. Allergic rhinitis in athletes management plan adapted from (Delgado, Moreira et al. 2006)

2.6.1 Environmental control

Reducing allergen exposure has proven to result in improving the severity of the disease and reducing the need for drugs (van Cauwenberge, Bachert et al. 2000). The beneficial effect may take weeks or months to be fully perceived (van Cauwenberge, Bachert et al. 2000). In most cases, and specifically in athletes, complete avoidance is unfeasible (Moreira, Kekkonen et al. 2007). Nevertheless, measures aiming to reduce relevant allergens should be promoted, and are considered as a first step in management. As far as house-dust-mites are concerned, there are some measures like removing carpets from the bedroom, careful and daily cleaning, and regular change of bed linen. Another inhalant allergen, quite important for athletes seasonal activity, are pollens. For athletes it is often impossible to avoid this stimuli due to its ubiquitous presence, but following pollen forecasts and adapting training venues, time of day and training using appropriate face equipment may minimize exposure, at least to peak pollen levels (Wallace, Dykewicz et al. 2008; Dijkstra and Robson-Ansley 2011). Irritants reported to cause nasal symptoms include tobacco smoke, pollution, chlorine and cold air (Wallace, Dykewicz et al. 2008). To prevent high level exposure to these agents some control of the training environment can be achieved improving ventilation systems of swimming pools and ice arenas (Delgado, Moreira et al. 2006) and taking measures to reduce global pollution, such as the one taken in the Chinese Olympic Games (Zhang, Wang et al. 2011). Allergic athletes should avoid outdoor training during pollen, ozone or air pollution alert periods.

2.6.2 Pharmacologic therapy of rhinitis in athletes

The selection of treatment for a patient depends on multiple factors: type of rhinitis, symptom severity, patient age and job (Wallace, Dykewicz et al. 2008). There is limited medical-evidence to what treatment options should be used in elite athletes. Management of allergic rhinitis should be adapted to accommodate factors that may hazard the athlete performance, and the balance between efficacy and safety should be addressed before prescribing. In elite athletes the drug must be accepted by the World Anti-Doping Agency (WADA) rules.

2.6.2.1 H1 anti-histamines

H-1 receptor antagonists or H1 anti-histamines are drugs that block histamine at H1-receptor level (neutral antagonists or inverse agonists). They are effective in symptoms mediated by histamine, namely rhinorrhoea, sneezing, nasal and eye itching (Bousquet, Khaltaev et al. 2008). The recommended treatment in the most updated guidelines for allergic rhinitis patients is the second-generation oral H1-anti-histamines (e.g. rupatadine, ebastine, azelastine, levocetirizine or desloratadine), that do not have anti-cholinergic and sedative, cognitive and psychomotor effects (Brozek, Bousquet et al. 2010). Athletes benefit the most with these choices, namely endurance athletes, since first generation H1 anti-histamines may reduce psychomotor skills by their sedative effect and, by their anticholinergic activity, cause mucosal drying and reduce sweating and temperature regulation (Delgado, Moreira et al. 2006; Dijkstra and Robson-Ansley 2011). Some authors even propose a cautious approach in the prescription of any anti-histamines 24-48h before a major competition (Dijkstra and Robson-Ansley 2011).

Intranasal H1-antihistamine (azelastine and levocabastine) are locally effective reducing itching, sneezing, runny nose and nasal congestion (Bousquet, Khaltaev et al. 2008). Due to their rapid and topical effects they can be used on demand by athletes to treat acute unexplained symptoms in the sport field (Delgado, Moreira et al. 2006). Ocular medication with anti-histamine compounds, using for example olopatadine (with a dual effect of mast cell stabilization), is quite effective in eye symptoms (van Cauwenberge, Bachert et al. 2000)

2.6.2.2 Decongestants

Decongestants, as vasoconstrictor drugs, act on the adrenergic receptor reducing nasal obstruction. Their side effects (increased blood pressure, heart rate, central nervous system stimulation) limit their use (van Cauwenberge, Bachert et al. 2000). Their clinical use should be limited to a short-term (<5 days) in order to avoid rhinitis *medicamentosa* and should not be used isolated (Brozek, Bousquet et al. 2010). Oral use should be carefully considered or avoided in the elite athletes because some of them are forbidden by WADA 2011. For example ephedrine and methylephedrine are prohibited when its concentration in urine is greater than 10 micrograms per milliliter, and pseudoephedrine when its urine concentration is greater than 150 micrograms per milliliter; doses under 150 micrograms per milliliter in urine are now being monitored in order to detect patterns of misuse (WADA 2011).

2.6.2.3 Corticosteroids

Intranasal glucocorticosteroids are the most efficacious medication available for allergic and non-allergic rhinitis treatment (Bousquet, Khaltaev et al. 2008; Scadding, Durham et al. 2008). These medications are safe to be used in athletes and effective in all symptoms of allergic rhinitis as well as ocular symptoms (Bousquet, Khaltaev et al. 2008). It is supported by high quality of evidence (Brozek, Bousquet et al. 2010) and meta-analysis (Weiner, Abramson et al.

1998) that intranasal glucocorticoids are more effective over oral and topical H1-antihistamines (Brozek, Bousquet et al. 2010), and can be used during competition. In a cross-sectional survey in 446 athletes, treatment with corticosteroids was associated with significantly improved nasal symptoms and quality of life (Alaranta, Alaranta et al. 2005). They have slow onset of action (12h) and maximum efficacy over weeks (van Cauwenberge, Bachert et al. 2000). A recent review of *Laekeman* concluded that inhaled corticosteroids require continuous therapy, at least for the symptoms duration (Laekeman, Simoens et al. 2010).
Systemic corticosteroids are indeed the last resort for allergic rhinitis treatment (van Cauwenberge, Bachert et al. 2000). They are prohibited by WADA when administered orally, rectally or by intravenous or intramuscular administration(WADA 2011). If these formulations are indeed necessary for disease treatment, a Therapeutic Use Exemption may give that athlete the authorization to take the needed medicine (WADA 2011).

2.6.3 Allergen immunotherapy

Allergen vaccines (specific immunotherapy; IT) are very effective in controlling symptoms of allergic rhinitis, can potentially modify the disease, and their clinical benefits may be sustained years after discontinuing treatment (Wallace, Dykewicz et al. 2008; Brozek, Bousquet et al. 2010). It is a valuable option, as stated in the 2010 ARIA guidelines, and indicated in symptomatic patients, with proven allergy (demonstrated by IgE antibodies or positive skin prick tests), with a significant and unavoidable exposure and whose symptoms are not controlled with pharmacological therapy (Wallace, Dykewicz et al. 2008). Athletes are frequently included in this group, namely in the case of pollen-allergic athletes who train and compete in outdoor environment, and with symptoms that affect their performance (Delgado, Moreira et al. 2006). This treatment when performed should be done by trained allergist and the athlete warned not to train in a few hours after immunotherapy injection, to reduce the risk of systemic reactions. Subcutaneous immunotherapy (SIT) is recommended in adults and children with seasonal and persistent allergic rhinitis caused by house dust mites (Brozek, Bousquet et al. 2010). In some cases sublingual specific immunotherapy (SLIT) can be used, namely in adults with rhinitis caused by pollens or house dust mites and in children in pollen-mediated allergy (Scadding, Durham et al. 2008; Brozek, Bousquet et al. 2010). Other forms of immunotherapy might be introduced, namely intranasal allergen specific immunotherapy in adults (Brozek, Bousquet et al. 2010)

2.6.4 Other potential treatment options

Other pharmacological treatments can be used in athletes, as a second line approach. Antileukotrienes inhibit inflammatory mediators produced in both allergic and nonallergic rhinitis, particularly after cold, allergen and exercise challenge (Delgado, Moreira et al. 2006). Recent guidelines recommend its use in seasonal allergic rhinitis in adults and children and only in children in the persistent form of rhinitis (Brozek, Bousquet et al. 2010).
Disodium cromoglycate and sodium nedocromil are used in allergic rhinitis as intranasal and ocular preparations. They are effective in some patients, have excellent safety profile, but its use 4 times a day compromises compliance (Scadding, Durham et al. 2008). Comparing to antihistamines they seem less effective (Brozek, Bousquet et al. 2010). They have a specific role in the prophylactic treatment of allergic conjunctivitis (Bousquet, Khaltaev et al. 2008)
Intranasal ipatropium bromide decreases rhinorrea inhibiting parasympathetic stimulation, but does not act in any other rhinitis symptoms (Bousquet, Khaltaev et al. 2008). For this, it

has a small role in allergic rhinitis, but may be useful in winter sports ("skiers nose") increasing the ability of the nose to warm and humidify the air, reducing watery rhinorrhoea caused by exposure to cold dry air (Katelaris, Carrozzi et al. 2003).
Topical saline is beneficial in chronic rhinorrhea and rhinosinusitis, when used as sole modality or in association with inhaled corticosteroids (Wallace, Dykewicz et al. 2008).
Anti-IgE (Omalizumab) use in allergic rhinitis is not proved cost-effective (Bousquet, Khaltaev et al. 2008). A possible indication for this therapy is in asthmatic patient with concomitant allergic rhinitis, with a clear IgE-dependent allergic component, and uncontrolled despite treatment (Kopp 2011).
Other options like homeopathy, acupuncture, herbal medicines and even physical techniques have not proven their efficacy (Brozek, Bousquet et al. 2010).

2.7 Allergic rhinitis as a risk factor for asthma in athletes

Asthma and allergic rhinitis frequently coexist (Bousquet, Khaltaev et al. 2008). The prevalence of asthma in patients with rhinitis varies between 10-40% and rhinitis seems to be an independent factor in the risk of asthma (Bonini, Bonini et al. 2006). It is not still clear whether allergic rhinitis is an earlier clinical manifestation of allergic disease in atopic patients who will develop asthma, or the nasal disease itself is a causative for asthma (Bousquet, Khaltaev et al. 2008). A very recent study with a 4 decades follow-up of nearly 2000 children found that childhood eczema and rhinitis in combination predicted both new-onset atopic asthma by middle age and the persistence of childhood asthma to adult atopic asthma (Martin, Matheson et al. 2011). *Ciprandi* in several studies evaluated the impact of allergic rhinitis in spirometry, bronchodilation and bronchial hyperreactivity results and found a persistent association (Ciprandi, Cirillo et al. 2008; Cirillo, Pistorio et al. 2009; Ciprandi, Cirillo et al. 2011).
Allergic rhinitis and asthma have some strong similarities on inflammation mechanisms. An eosinophilic type of inflammation is present in both upper and lower airways in rhinitic patients. In these patients, nasal allergen challenge can induce increased bronchial hyperresponsiveness, which might represent a sign of common inflammatory features (Bonini, Bonini et al. 2006). In fact, on nasal and bronchial mucosa a similar inflammatory infiltrate is seen, including eosinophils, mast cell, T lymphocytes, and monocytes with similar proinflammatory mediators (histamine, CysLT), Th2 cytokines and chemokines (Bousquet, Khaltaev et al. 2008). Perhaps the inflammation magnitude in these diseases, which represent the systemic response to allergy, may be different resulting in different manifestations (Bousquet, Khaltaev et al. 2008).
The management of allergic rhinitis also improves asthma control and reduces asthma severity (Bousquet, Khaltaev et al. 2008). Intranasal steroids seem to prevent seasonal increase in nonspecific bronchial hyperreactivity and asthma symptoms associated with pollen exposure, and reduce asthma symptoms, exercise-induced bronchospasm and bronchial responsiveness to methacoline (Bonini, Bonini et al. 2006). Three post-hoc studies described in the ARIA guidelines showed that allergic rhinitis treatment reduced potential utilization of healthcare for co-morbid asthma (Bousquet, Khaltaev et al. 2008).
Elite athletes commonly use drugs to treat asthma, exercise-induced bronchial symptoms and rhinitis. They should be adapted accordingly to WADA, and Therapeutic Use Exemptions should be made with appropriate diagnostic approach, namely medical history, physical examination, spirometry and beta-2 agonist reversibility bronchoconstrition and, if

necessary, bronchial provocation test to establish the presence of airway hyperresponsiveness.

Exercise-induced asthma (EAI) also occurs with allergic rhinitis patients, but frequently goes undiagnosed in children and athletes, because of normal spirometry and negative history (Bonini, Bonini et al. 2006). Every athlete should be screened for asthma or exercise-induced-asthma, including resting spirometry with bronchodilator response and, if not conclusive, bronchial provocation with methacoline or exercise challenge in the usual sports field environment or in a controlled environment in the laboratory (Delgado, Moreira et al. 2006).

3. Conclusion

Allergic rhinitis is a very common disease that in athletes may negatively impact athletic performance. Early recognition, diagnosis and treatment are crucial for improving nasal function and reduce the risk of asthma during exercise and competition. This population represents a diagnostic challenge for allergic conditions and are submitted to several risk factors. So, in order to avoid these risks, all elite athletes should be screened for atopy with skin prick tests and/or specific IgE blood tests, and allergic symptoms evaluated using validated and adapted questionnaires. Proper and accurate treatment will allow athletes to compete at the same level as the non allergic ones. For treatment, inhaled corticosteroids represent the first line of treatment in association with second-generation anti-histamines accordingly to the severity of symptoms. All athletes with rhinitis should be evaluated for asthma and exercise-induced asthma, in accordance to their association and the potential risk of allergic rhinitis for asthma.

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