

Exercise-induced respiratory symptoms and allergy in elite athletes: Allergy and Asthma in Polish Olympic Athletes (A²POLO) project within GA²LEN initiative

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Abstract

Introduction: Exercise-induced respiratory symptoms are often reported by professional athletes, but asthma and allergy are underdiagnosed. Few studies used standardized questionnaires combined with clinical assessment to investigate asthma and allergy among athletes.

Objectives: Assessment of the prevalence of allergy and asthma symptoms among Polish professional athletes and confronting it with clinical data.

Methods: Two hundred twenty-two Olympic athletes participated in the project being part of the Global Allergy and Asthma European Network (GA²LEN) Olympic study. Allergy and asthma status was determined using Allergy Questionnaire for Athletes (AQUA), spirometry, reversibility test, methacholine challenge and skin prick testing. Final diagnosis was established by an allergist.

Results: At least one exercise-induced asthma (EIA) symptom was reported by 28.4% athletes, and finally asthma diagnosis was established in 11.3% while only 5.9% of athletes had history of asthma. Reversibility test was positive in 36% of athletes finally diagnosed with asthma. Allergic rhinitis (AR) symptoms were reported by 27%, and the diagnosis was confirmed in 21% of athletes while only 9% had previously diagnosed AR. No significant differences in frequency of asthma and AR were observed between endurance and non-endurance athletes.

Conclusions: High prevalence of exercise-induced respiratory symptoms among top athletes is not reflected by asthma diagnosis. As it was expected, our data confirm that – in diagnosis of EIA – lung function testing alone is not useful, whereas reversibility tests are of limited value.

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Key words

allergic rhinitis – athletic performance – exercise-induced asthma – questionnaires – respiratory function tests

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Authorship and contributorship

MK and MLK participated in the conception and design of the study, in the analysis and interpretation of data, and in manuscript preparation; MK, JJ and HK participated in subjects' recruitment and clinical assessment.

Ethics

The study was approved by the local ethics committee and subjects gave informed consent for participation.

Conflict of interest

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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Introduction

Over the last few decades, there has been a constant increase in the prevalence of allergic diseases, and this increase has been observed worldwide. Recent epidemiological data show that the prevalence of asthma and allergy among competitive athletes is also increasing (1, 2). Furthermore, undiagnosed asthma and allergy may substantially impair sports performance. Although recently the restrictions on the use of most anti-asthma medications by athletes have been waived, and the possible breaking of the anti-doping regulations is of less concern, the criteria for diagnosing asthma in professional athletes are still being discussed (3, 4).

Studies on the prevalence of asthma and allergy in professional athletes had been initiated at the beginning of the 1980s. Screening for exercise-induced asthma revealed the presence of symptoms among 11% of US Olympians participating in the Los Angeles Games in 1984 (5). Among the Team USA members for the 1996 Summer Games, more than 15% had been previously diagnosed with asthma and almost 14% have ever had anti-asthma medication prescribed (6). In a similar study carried out among US Winter Olympians in Nagano 2 years later, 22% of athletes had previously been diagnosed with asthma, while over 18% had ever used asthma medication (7). According to more recent data (8), percentage of athletes using inhaled β -mimetics varied from 3.6% during Atlanta Summer Games to 7.7% among participants in the Winter Olympics in Turin in 2006. Higher prevalence of asthmatic symptoms in top athletes, when compared with the general population, has also been reported by other authors (9–11). In addition, there is a growing body of evidence indicating that the incidence of asthma may be associated with exercise intensity and a predominant pattern of exercise training that are typical for the so-called endurance sports (1, 11–13).

Although the association of both allergy and asthma with competitive-level exercise has been discussed for over two decades, few systematic surveys or studies have ever used standardized questionnaires and combined them with a clinical and functional assessment. Therefore, we sought to investigate the prevalence of self-reported allergy and asthma symptoms among a group of Polish professional athletes, and then confirm the validity of the questionnaire data with pulmonary function tests, allergy test results and a clinical diagnosis confirmed by an allergist.

Table 1. Number of athletes representing sport disciplines characterized by endurance and non-endurance pattern of exercise

	No. of athletes
Endurance sports	83
Canoe, kayak	34
Rowing	21
Cycling, mountain biking	11
Modern pentathlon	9
Swimming	5
Triathlon	3
Non-endurance sports	139
Volleyball	33
Handball	21
Track and field (except triathlon and modern pentathlon)	14
Sailing	10
Weightlifting	8
Fencing	8
Judo	8
Shooting	7
Archery	7
Tennis	6
Badminton	5
Windsurfing	4
Wrestling	3
Gymnastics	2
Boxing	2
Equestrian	1

Materials and methods

The study subjects were recruited from a group of Polish professional athletes preparing for participation in the 2008 Summer Olympic Games in Beijing, China. The Allergy and Asthma in Polish Olympic Athletes (A²POLO) study was part of a multicenter Olympic study within the framework of the Global Allergy and Asthma European Network of excellence project (GA²LEN) workpackage 2.8.2. Two hundred twenty-two athletes (140 males; 63.1%) participated in the study, of which 179 eventually qualified for the Polish Summer Olympic Team. The median age of the athletes included in this study was 26 years. After further analyses, athletes were eventually subdivided based on their predominant pattern of exercise (endurance vs non-endurance – Table 1) and physician-diagnosed asthma or allergic rhinitis (AR).

Participants filled out the Allergy Questionnaire for Athletes (AQUA[®]), which was developed and validated by Bonini *et al.* (14) using Italian soccer players and is intended for use as an allergy screening tool in competitive athletes. The questionnaire is protected by

copyright, and its non-commercial use was kindly permitted by the authors. A Polish language version of AQUA® was prepared at the Department of Immunology, Rheumatology and Allergy at the Medical University of Łódź, Poland. In summary, AQUA® contains just 25 questions, and those that result in a positive response (suggesting allergy and asthma symptoms) have each their answers assigned a value from 1 to 5. A total AQUA® score of ≥ 5 has the best predictive value for allergy (0.94) with a specificity of 97.1% and a sensitivity of 58.3% (14). AQUA questions concerning various allergy and asthma symptoms were applied in our study separately for evaluation and stratification of athletes, yet it has to be underlined that it was the total AQUA score result, and not an individual question, that was used to identify athletes with increased probability of asthma or allergy.

The final diagnosis was established by an allergist either at the National Centre for Sports Medicine (COMS) in Warsaw, Poland, or at the Department of Immunology, Rheumatology and Allergy at the Medical University of Łódź, Poland, and was based on patient history and clinical assessment, along with the results from skin prick testing (SPT) and lung function testing.

Lung function assessment

Lung function testing was performed using a CPFS/D™ spirometer (MedGraphics, St. Paul, MN, USA) in accordance with the guidelines issued by the European Respiratory Society and American Thoracic Society (ATS) (15, 16). Athletes already taking anti-asthma medication were asked to temporarily discontinue their drug at a certain time before the study, with the timing of the last dose being dependent on the class of their anti-asthma medication: 24 h for long-acting beta agonists, 12 h for short-acting beta agonists, 7 days for inhaled corticosteroids and 5 days for leukotriene modifiers. Initially, three technically acceptable expiratory maneuvers were performed using the CPFS/D™ spirometer. The largest forced expiratory volume in 1 s (FEV₁) value of the three was then recorded and used as the baseline for the reversibility test. During the reversibility test, the athletes were instructed to inhale 400 µg of nebulized salbutamol (bronchodilator) through the pressurized metered dose inhaler. After waiting for 15 min, the patient repeated the spirometry test, again using the CPFS/D™ spirometer. The change in FEV₁ was calculated from the formula:

$$\Delta FEV_1 = 100 \times \frac{(FEV_1 \text{ postsalbutamol} - FEV_1 \text{ baseline})}{FEV_1 \text{ baseline}}$$

According to the ATS guidelines (16), reversibility test results were considered positive if, after salbutamol inhalation, FEV₁ increased by 12% and 200 mL from baseline value.

Methacholine challenge test

A nonspecific bronchial challenge using methacholine was carried out in accordance with the guidelines issued by ATS (17) using an inhalation system for allergen provocation that was compatible with the Lungtest 1000 spirometer (MES, Kraków, Poland). The challenge was considered positive if the fall in FEV₁ was 20% or more compared with FEV₁ after inhalation of phosphate-buffered saline. Concentrations of inhaled methacholine ranged from 0.031 to 16 mg/mL, and a 2-min tidal breathing dosing protocol was employed. If FEV₁ fell less than 20% after inhalation of methacholine at 16 mg/mL, the challenge was considered negative.

SPTs

SPTs were performed with the following seasonal and perennial allergens: hazel, alder, birch, mixed grasses, *Platanus*, cypress, olive tree, mugwort, ragweed, *Alternaria*, *Cladosporium*, *Aspergillus*, *Parietaria*, feline, canine, cockroach, *Dermatophagoides pteronyssinus* and *D. farinae*. Allergen extracts were purchased from Allergopharma (Reinbek bei Hamburg, Germany).

Statistics

Statistical analyses were carried out using STATISTICA 7.0 (StatSoft, Tulsa, OK, USA), GraphPad Prism 4.00 for Windows (GraphPad Software, San Diego, CA, USA) and other statistical software available online (18). When comparing the numerical values between two groups, the Mann–Whitney *U*-test was used. For three or more groups, one-way ANOVA was employed. Dunn's test was used for *post hoc* analysis. Comparisons of frequency of symptoms and diseases were done using χ^2 test with Yates' correction. A *P* value less than 0.05 was considered a criterion for statistical significance.

Results

Asthma symptoms and diagnosis

At the time of the study, 63 athletes (28.4%) reported in the questionnaire at least one asthma symptom associated with exercise: cough and/or shortness of breath were reported by 50 (22.5%) and chest tightness

Table 2. Asthma and allergy symptoms and selected lung function parameters in endurance and non-endurance athletes

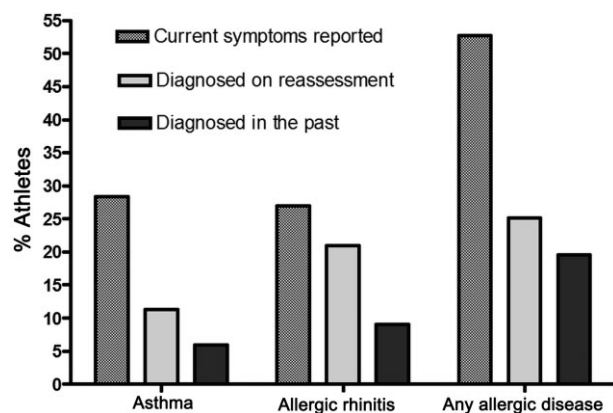
	Endurance athletes	Non-endurance athletes	<i>P</i> value
No. of subjects (%)	83 (37.4%)	139 (62.6%)	
Male/female	60/20	82/41	
Age in years (median)	25	26	>0.05
Chest tightness, wheezing (% athletes)	12.5%	19.4%	>0.05
Shortness of breath, cough (% athletes)	26.3%	20.9%	>0.05
Asthma (% athletes)	11.25%	12.95%	>0.05
Allergic rhinitis (% athletes)	18.75%	22.3%	>0.05
Baseline FEV ₁ (median; % predicted)	106	100	0.005
Δ FEV ₁ post-salbutamol (median; %)	4	4	>0.05
MEF 25–75 (median; % predicted)	96	98	>0.05
Red eyes, itchy or watery eyes (% athletes)	3.8%	17.3%	0.007
Sneezing, rhinorrhea, nasal itching (% athletes)	21.3%	30.2%	>0.05

Statistically significant values given in bold print.

FEV₁, forced expiratory volume in 1 s; MEF 25–75, maximum expiratory flow between 25% and 75% of forced vital capacity.

and/or wheezing by 37 (16.7%) athletes. No significant differences were observed between endurance and non-endurance athletes with regard to the prevalence of asthma symptoms (Table 2).

Finally, after clinical evaluation, asthma was eventually diagnosed by a physician in 25 (11.3%) athletes. In contrast, only 13 of the 222 athletes (5.9%) have had a previous history of physician-diagnosed asthma (Fig. 1), and anti-asthma medications were taken in the past by 19 (8.6%) athletes (inhaled beta2-agonists, 5.6%; inhaled corticosteroids, 1.9%; and leukotriene modifiers, 2.8%)

**Figure 1.** Percentage of athletes with currently reported symptoms of asthma and allergy diagnosed upon clinical reassessment and having positive history of allergy diagnosis.

Respiratory function testing results and asthma symptoms in athletes

Lung function testing was performed in 190 out of the 222 participating athletes (85.6%) due to the restricted availability of some athletes as a result of their training schedules. Baseline FEV₁ (percentage of predicted value) was significantly higher in endurance athletes than in the non-endurance group (median values 106% predicted vs 100% predicted, respectively; $P = 0.005$) – Table 2. Although significantly lower FEV₁ values were noticed in athletes diagnosed with asthma compared with non-allergic, non-asthmatic athletes, or athletes with AR, surprisingly only 4 of the 25 athletes with a confirmed diagnosis of asthma had FEV₁ value lower than the 80% predicted (Fig. 2).

A positive result of the reversibility test was documented in 14 athletes (7.3%), nine of whom already had their asthma diagnosis – meaning that slightly more than one third (36%) of the 25 athletes diagnosed with asthma had a positive reversibility test with a bronchodilator. Interestingly, although a 200 mL or more increase in baseline was observed in 22 out of the 25 asthmatic athletes (88%) (vs a 53.3% FEV₁ increase in athletes with AR and a 45.7% FEV₁ increase in the non-allergic, non-asthmatic athletes; $P = 0.001$), it turned out that only 9 of these same 25 athletes (36%) had met the second mandatory criterion of a 12% increase in FEV₁ to be considered asthmatic. Methacholine provocation was performed in 28 (12.6%) athletes (13 of them had reported respiratory symptoms in the AQUA questionnaire). The test was positive in

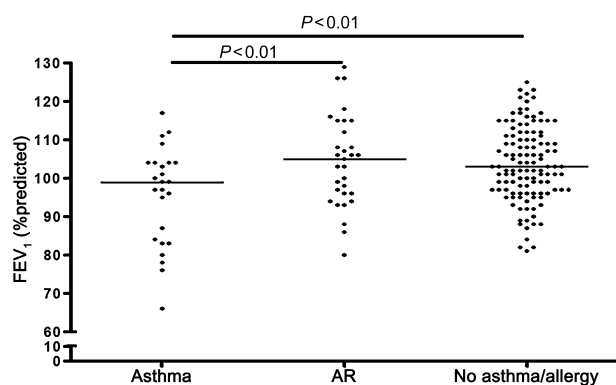


Figure 2. Baseline FEV₁ values in athletes with and without asthma or allergy diagnosis. One dot represents one subject. Median values marked with horizontal lines. AR, allergic rhinitis; FEV₁, forced expiratory volume in 1 s.

18 of these 28 athletes (64.3%): 7 with and 11 without a history of asthma diagnosis. No significant difference in the prevalence of positive methacholine challenge between athletes reporting or not reporting respiratory symptoms was observed (61.5% vs 66.7%, respectively; $P > 0.05$), although the objective and measurable degree of bronchial hyperresponsiveness was significantly higher in those athletes who originally reported respiratory symptoms than in the asymptomatic group (methacholine PC₂₀ 1.57 ± 0.52 mg/mL vs 3.80 ± 0.80 mg/mL, respectively; $P = 0.035$).

Allergy symptoms and diagnosis

Thirty-six athletes (16.2%) have had a history of allergies (other than asthma) diagnosed by a physician: AR was previously diagnosed in 9% of the athletes, allergic conjunctivitis in 6.8%, food allergy in 3.6%, venom allergy in 2.7%, drug allergy or hypersensitivity in 1.8%, urticaria in 0.9%, and eczema in 0.45% of athletes. Additionally, 40 out of 179 athletes without physician-diagnosed allergy (22.3%) suspected themselves of being allergic. Forty-eight athletes (21.9%) reported ever taking anti-allergic medication, of which antihistamines were the most frequently used (15.7%).

During clinical evaluation, symptoms of rhinitis (such as sneezing, watery discharge and/or itching) were reported by 27.0% of the athletes. No significant differences were observed between endurance and non-endurance athletes with regard to the prevalence of rhinitis symptoms, but ocular symptoms (conjunctival hyperemia, lacrimation, itching) occurred more frequently in non-endurance athletes (17.3% vs 3.8%; $P = 0.007$) – Table 2. SPTs that were positive for at least one allergen were found in 38.9% of the athletes, and

the most frequent sensitizing allergens were house dust mites (19.6%), mugwort (16.7%) and grasses (16.2%) – Table 3. Finally, as the results of clinical evaluation and skin testing were compiled, AR was ultimately diagnosed by a physician in 46 (21.0%) of the 222 athletes.

In summary, the prevalence of asthma and AR, as diagnosed by an allergist during this study, turned out to be more than twice as high as previously diagnosed, although lower than the prevalence of self-reported asthma and rhinitis symptoms (Fig. 1). No significant differences in the frequency of physician-diagnosed asthma and AR were observed between endurance and non-endurance athletes ($P > 0.05$, χ^2 test – Table 2).

Analysis of the AQUA score

For the group of Olympic athletes as a whole, the median AQUA score value was 3. No differences in AQUA scores were observed between endurance and non-endurance athletes (median 2 vs 3.5; $P = 0.15$). Both in asthmatic and in rhinitic athletes, median AQUA score values were significantly higher compared with non-allergic athletes (15 vs 11 vs 1, respectively; $P < 0.0001$) – Fig. 3.

In 96 athletes (43.8%), their AQUA score value was 5 or higher. Within this group, 52.8% had not been previously diagnosed with any allergic disease. Among the athletes with an AQUA score between 0 and 4 points ($n = 123$), none had ever been diagnosed with allergies. Among athletes with AR, an AQUA score of 5 or above was observed in 77.4% subjects, in asthmatic athletes a score of 5 or above was observed in 74.1% subjects,

Table 3. Frequency of positive skin prick tests (SPT) with selected seasonal and perennial allergens in Polish Olympians

Allergen source	% Athletes with positive skin prick test
House dust mites	19.6
Mugwort	16.7
Grasses	16.2
Birch	15.7
Alder	13.7
Hazel	12.7
Dog	11.3
Cockroach	10.3
Cat	7.4
Ragweed	6.9
Alternaria	3.9
Cladosporium	1.5

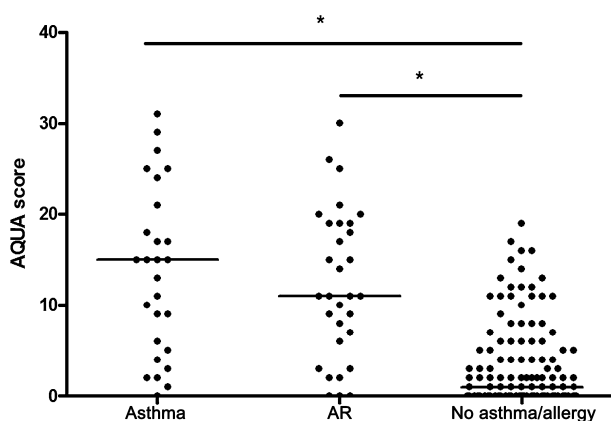


Figure 3. AQUA© score in athletes diagnosed with asthma, allergic rhinitis (AR) and in non-allergic non-asthmatic athletes. One dot represents one subject. Median values marked with horizontal lines. $P < 0.0001$, Kruskal–Wallis test; $*P < 0.001$, Dunn's *post hoc* test. AQUA, Allergy Questionnaire for Athletes.

while in non-allergic, non-asthmatic athletes an AQUA score of 5 or above was reported in just 21.7% of subjects.

In the same group of 96 athletes with an AQUA score ≥ 5 , nasal symptoms were reported by 58.3%, cough and dyspnea by 40.6%, and chest tightness by 34.4% of athletes. Among athletes with an AQUA score between 0 and 4, the most frequent symptoms reported in the questionnaire were cough and dyspnea (8.13%), and all of these athletes reported as never having had any symptoms of rhinitis. The mean AQUA score was significantly higher in atopic athletes compared with non-atopic athletes (9.49 ± 0.93 vs 4.27 ± 0.50 , respectively; $P = 0.00001$), and the AQUA score (for individual questions) in atopics more frequently reached a value of 5 or above (56.8% vs 31.0% of non-atopics, $P = 0.0004$; χ^2 test) than for non-atopic athletes.

Discussion

In this study, we have analyzed a history of asthma and allergy symptoms and assessed respiratory function in a relatively large and heterogeneous group of top-level athletes while they were preparing for the Summer Olympic Games in Beijing. The heterogeneity of the studied group in terms of its varied sport disciplines could be considered by some as a drawback of the study, but at the same time the significant number of participants allowed for the assessment of the preva-

lence of asthma and allergic symptoms among athletes who are at a similar level of training.

The prevalence of diagnosed asthma among Olympic athletes (5.9%) was similar to the prevalence reported in the general Polish population (19), but a significantly higher proportion of athletes reported classical symptoms of asthma during exercise in their AQUA questionnaire (16.7% chest tightness/wheeze, 22.5% cough/dyspnea and 28.4% at least one symptom typical for asthma). Interestingly, as opposed to previous studies (6, 11, 12, 20, 21), the frequency of asthma symptoms was similar among athletes performing endurance and non-endurance sports.

Clinical evaluation of these athletes by an allergist, having access to medical history, and respiratory function assessment and allergy testing allowed for the establishment of a final diagnosis of chronic bronchial asthma in 25 athletes (i.e. 11.3%). This figure is almost twice the prevalence based on earlier diagnoses of asthma in this group of athletes, but is significantly lower than the frequency of exercise-induced respiratory symptoms self-reported by athletes.

These data confirm the previously reported (22, 23) underdiagnosis of chronic asthma among professional athletes. On the other hand, the high prevalence of exercise-induced respiratory symptoms, which were reported by almost 1/3 of the athletes, points to a significant discrepancy between a diagnosis of asthma based on Global Initiative for Asthma criteria and the presence of exercise-induced bronchospasm. Subjects who experience symptoms during or after exercise, but who are not diagnosed with persistent asthma (in the absence of chronic asthma symptoms), should therefore be considered as having an isolated exercise-induced bronchoconstriction.

Arriving at a diagnosis of asthma in athletes is influenced by several factors. Symptoms of asthma are, in part, similar to those brought about by respiratory infections (e.g. common colds), and as such may often be misinterpreted by athletes leading them to not seek further treatment (24). Moreover, symptoms such as dyspnea, cough and shortness of breath are frequently regarded as an imminent part of strenuous exercise training, and are in many cases not considered as potentially related to a disease. This may result in the overall underdiagnosis and eventual undertreatment of asthma in athletes.

Baseline FEV₁ in asthmatic athletes, while slightly lower than that seen in athletes without asthma, was still within the normal range (80% or more of predicted value) in all but four subjects. Reversibility testing with a bronchodilator turned out to be positive only in 1/3 of the athletes diagnosed with asthma, but

in addition five athletes without an asthma diagnosis also had a positive reversibility test with salbutamol. One could speculate that the presence of airway reversibility in otherwise asymptomatic athletes may reflect the presence of subclinical airway obstruction, not sufficient to cause symptoms, but its significance remains unknown and may deserve further evaluation.

In 60% of the athletes who were diagnosed with persistent asthma, an increase in FEV₁ from baseline after salbutamol inhalation did not reach the 12%, which is the required threshold for positive challenge. At the same time, a considerably higher number of asthmatic athletes (88%) demonstrated FEV₁ increases larger than 200 mL from pre-bronchodilator values. This discrepancy is most probably caused by the high baseline FEV₁ values seen in this particular and selected population. As a result, even a substantial FEV₁ increase in absolute value would not constitute a 12% increase from baseline. Our results indicate that lung function testing and bronchodilatation test are of limited value in the diagnosis of asthma among athletes.

Unfortunately, data acquired during nonspecific bronchial challenges with methacholine came from a limited number of subjects and are therefore partially biased, since athletes who had been strongly suspected of having asthma were referred for methacholine testing on a preferential basis. However, the possibility for a positive challenge was found among athletes whether they were eventually diagnosed or not diagnosed with asthma, and in a similar proportion to the athletes reporting respiratory symptoms and those who did not report respiratory symptoms. These data may, therefore, suggest a limited specificity and sensitivity to the methacholine challenge, which is supposed to confirm exercise-induced asthma among top athletes.

Similarly to asthma, AR symptoms were almost three times more prevalent than the actual diagnosis of AR made in the past, and in most patients reporting symptoms in the questionnaire, the diagnosis of AR was eventually confirmed by a clinician. The prevalence of an AR diagnosis was 21% and did not differ from that reported in the general Polish population (19). Similarly, the presence of atopy defined by positive SPTs was nearly at the same level as in the adult Polish population (19). Although we have also observed a higher prevalence of eye symptoms in non-endurance athletes as compared with endurance athletes (Table 2), the studied group was too heterogeneous in terms of sport disciplines in order to speculate on the possible influence of exercise pattern or training environment on the development of eye symptoms.

In our study, the validated AQUA questionnaire was used for the initial screening of asthma and allergy

symptoms in athletes (14). Over 40% of the athletes had an AQUA score reaching the value considerably associated with probability of allergy diagnosis. Simultaneously, more than half of those with increased AQUA score had never been diagnosed with allergy. This discrepancy becomes even more striking when compared with the presence of relatively low prevalence of self-reported allergy/asthma symptoms in athletes with AQUA ≥ 5 nasal (only 60% of those athletes had nasal and 40% asthma symptom).

The frequency of a previous diagnosis of allergic diseases in athletes participating in our study was similar to that observed in general population of Poland (19, 25). This was different from the situation seen in German athletes participating in the GA²LEN Olympic study (21), where athletes reported more frequently the presence of asthma and/or AR diagnosed in the past. However, clinical reassessment of Polish Olympic athletes resulted in an increase in the percentage of those diagnosed with AR to 21% and with asthma to 11%. These numbers are higher than in general Polish population. The percentage of athletes diagnosed with AR and/or asthma was even higher among those having an AQUA score ≥ 5 . On the other hand, only 4% of asthmatics and 6% of rhinitis subjects were among those scoring between 0 and 4 points in AQUA. These data still leave some room for other methods of identification of allergic athletes. Thus, among heterogeneous Olympic athletes, an AQUA score lower than 5 points seems to have a high negative predictive value, but a higher score (i.e. ≥ 5) appears to have low positive predictive value for the diagnosis of allergy.

This study documented the high prevalence of exercise-induced respiratory symptoms among top athletes, although the diagnosis of asthma in this group is considerably less frequent. The question of link between asthma symptoms and strenuous exercise appears more important in view of recent data on more prevalent asthma-like symptoms in physically active subjects from general non-athletic population (26). Furthermore, athletes already diagnosed with asthma in the past were not properly treated: only 1.9% were taking inhaled steroids while almost 6% had an established diagnosis of asthma. Thus, asthma appears to be underdiagnosed and probably undertreated in professional athletes. This undertreatment may not only limit their performance, but can also result in a substantial health hazard. These observations suggest a lack of awareness of exercise-induced asthma among athletes, sports professionals and medical personnel. Therefore, efforts at the European and worldwide level should be made to increase allergy awareness among

athletes, their coaches and medical professionals at different settings.

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