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# RESPIRATORY TRACT DYSFUNCTION IN SPORTSMEN

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**Abstract**

***Actuality.*** Increasing number of macrocycles during athletes' training focused on the achievement of high sports results leads to lower adaptive potential and as a result to the pre and pathological conditions, including – respiratory tract dysfunction. ***The aim*** – to analyze prevalence and reasons of respiratory tract dysfunction in athletes of high qualification. ***Results.*** The analysis of modern scientific data indicates high prevalence of asthma among professional sportsmen, skiers – 14–55 %, swimmers – 13–44 %, long-distance runners – 15–24 %. Professional sportsmen have got induced by physical loading laryngeal obstruction that is the main reason of larynx obstruction. The prevalence of this pathology among healthy population is ~ 5 % while among athletes – from 35 % to 70 %. Symptoms that indicate the infection of upper respiratory tract are between 30 to 40 % of the complaints of professional sportsmen in health facilities, especially among runners, cyclists, skiers, swimmers, rowers, and – tennis players and gymnasts. Currently, many experts hold to the hypothesis of «non-infectious» nature of symptoms of URTI, likely of allergic nature. Risk factors, mechanisms of respiratory tract dysfunction in sportsmen were analyzed.

***Conclusions.*** The prevalence of respiratory tract dysfunction (asthma, induced by physical loading laryngeal obstruction, chronic cough, respiratory infections) among qualified athletes is much bigger than among the normal population. Determining risk factors are atopy, ventilatory needs of the kind of sport and training environment.

**Key words:** bronchial asthma, bronchial hypersensitivity, respiratory tract infections, throat obstruction, sportsmen.

**Зіновій Остап'як, Ігор Випасняк, Богдан Лісовський, Тетяна Мицкан. Дисфункція дихальних шляхів у спортсменів.** ***Актуальність.*** Збільшення кількості макроциклів підготовки спортсменів, орієнтованих на досягнення високих спортивних результатів, призводить до зниження адаптаційного потенціалу і, як результат, – до виникнення перед- та патологічних станів, у тому числі, дисфункції дихальних шляхів. ***Мета дослідження*** – проаналізувати поширеність та причини респіраторної дисфункції в спортсменів високої кваліфікації. ***Результати.*** Проведений аналіз сучасних наукових даних свідчить про значну поширеність бронхіальної астми серед професійних спортсменів (лижники – 14–55 %, плавці – 13–44 %, бігуни на довгі дистанції – 15–24 %). У спортсменів-професіоналів індукована фізичним навантаженням обструкція гортані є основною причиною обструкції гортані. Поширеність цієї патології серед здорового населення складає ~ 5 % тоді як у спортсменів – від 35 до 70 %. Симптоми, які свідчать про наявність інфекції верхніх дихальних шляхів, складають 30–40 % звернень професіональних спортсменів у спортивно-медичні заклади, насамперед у спортсменів-бігунів, велосипедистів, лижників, плавців, веслярів, а також тенісистів і гімнасток. На сьогодні багато фахівців притримуються гіпотези про «неінфекційний» характер симптомів URTI, імовірніше, алергічного характеру. Проаналізовано фактори ризику, механізми порушення функції дихальних шляхів у спортсменів.

***Висновки.*** Поширеність дисфункції дихальних шляхів (астма, індукована фізичним навантаженням обструкція гортані, хронічний кашель, інфекції дихальних шляхів) серед висококваліфікованих спортсменів значно більша, ніж серед звичайних людей. Визначальними чинниками ризику є атопія, вентиляторні потреби виду спорту й тренувальне середовище.

**Ключові слова:** бронхіальна астма, гіперчутливість бронхів, інфекція дихальних шляхів, обструкція гортані, спортсмени.

***Актуальность.*** Увеличение количества макроциклов подготовки спортсменов, ориентированных на достижение высоких спортивных результатов приводит к снижению адаптационного потенциала и, как результат, – к возникновению перед- и патологических состояний, в том числе дисфункции дыхательных путей. ***Цель исследования*** – проанализировать распространенность и причины респираторной дисфункции у спортсменов высокой квалификации. ***Результаты.*** Проведенный анализ современных научных данных свидетельствует о значительной распространенности бронхиальной астмы среди профессиональных спортсменов: лыжники – 14–55 %, плавники – 13–44 %, бегуны на длинные дистанции – 15–24 %. У

спортсменов высокой квалификации индуцированная физической нагрузкой обструкция гортани является основной причиной обструкции гортани. Распространенность данной патологии среди здорового населения составляет ~ 5 % в сравнении у спортсменов –35 до 70 %. Симптомы, свидетельствующие о наличии инфекции верхних дыхательных путей, составляют 30–40 % обращений профессиональных спортсменов в спортивно-медицинские учреждения, прежде всего, у спортсменов-бегунов, велосипедистов, лыжников, пловцов, гребцов, а также – теннисистов и гимнасток. В настоящее время многие специалисты придерживаются гипотезы о «неинфекционном» характере симптомов URTI, вероятно аллергического характера. Проведен анализ факторов риска, механизмы нарушения функции дыхательного тракта у спортсменов.

***Выводы.*** Распространенность дисфункции дыхательных путей (астма, индуцированная физической нагрузкой обструкция гортани, хронический кашель, инфекции дыхательных путей) среди высококвалифицированных спортсменов значительно больше, чем среди обычной популяции. Определяющими факторами риска являются атопия, вентиляторные потребности вида спорта и тренировочная среда.

**Ключевые слова:** бронхиальная астма, гиперчувствительность бронхов, инфекция дыхательных путей, обструкция гортани, спортсмены.

**Introduction.** A distinctive feature of modern sport is a significant increase in the number of critical events during an annual macrocycle and four-years Olympic training period. This factor influenced the change in the structure of the annual training of athletes. The result of these changes was to increase the number of macrocycle training aimed at achieving and maintaining a high level of integrated athlete training for a competition period. This usually leads to lower adaptive capacity and, consequently, to an increase of injuries, pre–emergence and pathological conditions. The problems of respiratory diseases such as airway hypersensitivity (AHR) / asthma, exercise-induced laryngeal obstruction (EILO), chronic cough, respiratory infections are particularly relevant for highly skilled athletes who are engaged in various sports [2; 6; 16; 20].

The aim of this study was to analyze the prevalence and causes respiratory dysfunction in athletes qualifications.

Research methods. To achieve this goal were used theoretical methods: analysis, synthesis, induction, deduction

Research results. Discussion. The prevalence of AHR / asthma among athletes is from 10 to 17,2 % [3; 4; 10; 12].

As seen from the table. 1, between sports there is great variability in the level of prevalence of exercise-induced asthma – EIA / exercise induced bronchoconstriction – EIB athletes [21].

*Table 1*

**Prevalence EIB/EIA Among Sportsmen in Different Sports**
**Sport Prevalence of EIB/EIA, *%***

| **Sport Prevalence** | **EIB / EIA, *%*** |
|---|---|
| Cross country skiing | 14–55 |
| Skiing, jumping | 4 |
| Speed skating | 12–43 |
| Ice Hockey | 15 — 35 |
| Hockey | 5 |
| Figure skating | 35 |
| Swimming | 13–44 |
| Diving | 4 |
| Running | 15–24 |
| Cycling | 16–17 |
| Triathletes | 25–56 |
| Olympic sports | 17 |

Obviously, sports related physical activities with high endurance, in which athletes have to inhale large amounts of air increases the risk of EIB / EIA. For example, – Olympian skiers – who are participating in competitions and in the Nordic Combined ski race when the level of ventilation reaches 200 l / min over a long period of time and which often compete with low ambient temperatures, are more likely to develop EIB / EIA – 14–55 %. Despite such weather training skiers and jumpers jumping prevalence of the disease in the past is less than 4 % as they inhale large amounts of cold dry air. In addition, athletes who inhale various irritants, pollutants or allergens present in the air are exposed to an increased risk of EIB / EIA. More than

13–44 % Olympian swimmers and 13 % suffer synchronisors EIB / EIA [14]. Breathing air containing bleach (e.g chlorinated derivative) during many hours of training in the indoor pool is causing the high prevalence of EIB / EIA athletes in water sports. Unlike the aforementioned water sports, jumping into the water does not require training for endurance, but mostly held in closed chlorinated pools and the prevalence of disease in these sports is less than 4 % as they inhale large amounts of cold dry air. The traditional view is that the fins naturally gravitate to sail through pre-existing respiratory diseases has been questioned work [14; 16].

Athletes training and competitions are held in closed rollers, inhale cold air and can be exposed to particulate matter and nitrogen oxides emitted filling machines. The Olympic competitions in speed skating, which refers to endurance sports, the prevalence of EIB / EIA is 12–43 %. Hockey players and figure skaters breathing the same air, but none of these groups of athletes are not trained for endurance, but the risk of EIB/ EIA they also increased – 15–35 %, partly due to poor air quality in indoor ice arenas [20], while in hockey on grass – 5 %. Olympian cyclists who spend many hours training on the roads and are often subjected to the impact of particulate matter, nitrogen oxides, ozone and allergens also in the group with high proliferation EIB / EIA ~ 17 % [2]. It is not surprisingly, that in the Olympic triathletes, especially sport, which includes the effect of the environment and training schedules as swimmers and cyclists, marked the highest percentage of incidence of EIB / EIA – 25–56 %.

The results of operations related to the prevalence of the disease are consistent with the concept, which is that atopy, fan needs of the sport and training environment – determinants of risk of EIB / EIA in elite athletes [5; 9].

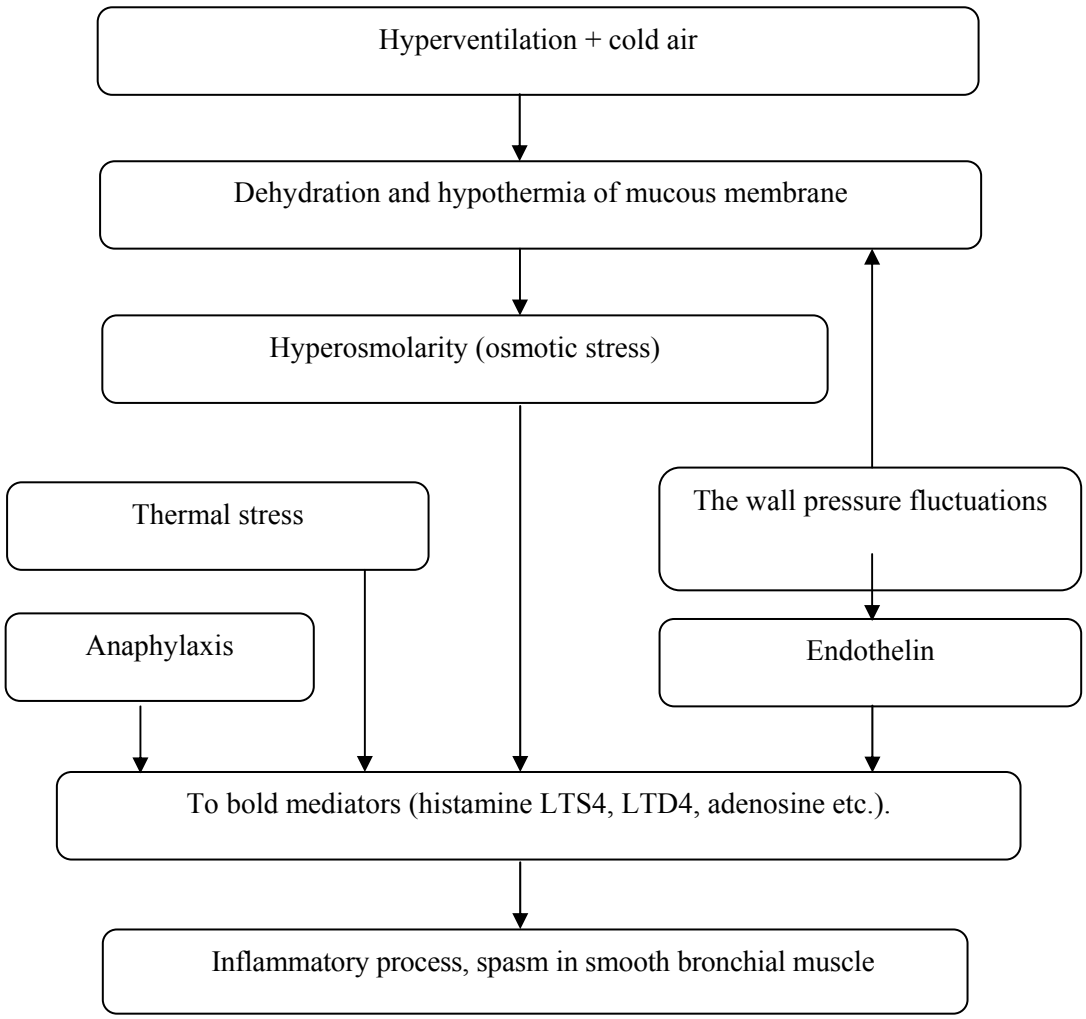


**Fig.1.** *Mechanisms of AHR in Athletes*

As shown in figure 1 of breathing at high velocity of air flowing for a long time leads to drying and cooling airway mucous membrane due to excessive evaporation of the liquid from the surface and significant dehydration and hypothermia of mucous membrane in the respiratory tract. Dehydration leads to hiperosmolarity (osmotic stress). The main reason for the release of mediators by changing the osmolarity can be modified ionic interactions in the cell and is an incentive for the release of mediators histamine, LTS4, LTD4 and adenosine et al., Which leads to inflammation and eventually to airway narrowing [6].

Inhalation of cold air cooling strengthens of the mucous membrane, causing its reactive hyperemia, edema and also enhances the obstruction. After cooling airway mucosa during exercise, followed by rapid heating airways after exercise, can serve as an additional stress, so-called «thermal stress» [9].

During hyperventilation increases strength and angles of the wall pressure, which increases dehydration of epithelial cells, leading them even to the complete detachment [14]. Furthermore, re-stretching and contraction of airway epithelial cells at high velocity, air flow could adversely affect the function of epithelial cells. Endothelin produced by the cells of the bronchial epithelium and endothelium may increase airway response to exercise by increasing the tone of smooth muscles and increased permeability of microcirculation and output cytokines involved in the acute phase of inflammation. Despite the ability of airway epithelium to a rapid recovery, repeated trauma followed by reduction considered as a cause structural and functional changes. These are the structural changes (airway reconstruction) obtained by the method of bronchoscopy in elite swimmers and cross–country racers [11].

Another factor that increases or causes bronchospasm may be redistribution of blood from the intestines to the early exercise of mast cells and transport of swallowed allergens in the lining of the airways, leading to NAIVE anaphylaxis [20].

An important condition to identify asthma in athletes is that they do not act only as bronchospasm, but as other objective criteria. The proper formulation of diagnosis and differential diagnosis of asthma requires a comprehensive assessment of disease history, results of clinical examination and appropriate laboratory and function tests.

The International Olympic Committee has several recommendations for the diagnosis of EIA in athletes, to enable the use of anti-asthma drugs: positive history of the disease and at least one positive provocative test [6]. Protocols of provocative tests are standardized and published.

*Table 2*

**Diagnostic Asthma Tests Recommended by The Medical Commission (MC) of the International Olympic Committee (IOC) and World Anti–Doping Association (WADA)**

| Methods | Criteria |
|---|---|
| Spirography | FEV1<70 %, FEV1/VC <55 % |
| Bronchodilation test | ↑ FEV1 ≥ 12 % (>200 мл) |
| Hyperventilation test (EVH) | ↓ FEV1 ≥ 10 % |
| Physical activity | ↓ FEV1 ≥ 10 % |
| Methacholine test | ↓ FEV1 ≥ 20 % при:<br>– PC20 ≤ 4 mg/ml (the athletes who were not taking inhaled corticosteroids;<br>– PC20 ≤ 16 mg/ml (the treatment with inhaled corticosteroids more than 1 month.) |
| Hyperosmolar test (inhaled mannitol) | ↓ FEV1 ≥ 15 % |

Baseline spirometry is a poor predictor of asthma in professional athletes as well as indicators of lung function may be within the normal range, but in fact, they are underestimated as for the athlete, so in this case is only forced expiratory volume in the first second (FEV1), since this has the best rate and reproducibility of diagnostic value [1].

To assess the reversibility of obstruction used bronchodilation test beta–2–agonists, short-acting (salbutamol). It should be noted that this test can be diagnostically significant only at the initial bronchial obstruction. From resulted above provocation tests – EVH is the most sensitive test for the detection of highly EIB in athletes. Many experts count it «gold standard» for the diagnosis of asthma. But it is believed that holding only EVH enough, especially in athletes with borderline results, and to prevent misdiagnosis it is recommended to use in the diagnosis of asthma 2–3 provocative tests [1; 6; 15; 19].

EVH can also be used as a method of screening in athletes without symptoms of EIB.

Ambiguous Recommendations on conducting methacholine test, not all experts proponents of the study, explaining that with different pathogenetic mechanisms of asthma in athletes it is shallow and Bougault V., Turmel J., Boulet L. P. [6] believe that this test with EVH should be mandatory when examining athletes. Anderson S. D., Kippelen P. [11] it is recommended to inhaled mannitol as highly provocative test in athletes.

And it should be noted that testing should be conducted at different times of the year. With indirect methods for diagnostic purpose as pulse ostsylometriya [23], the definition of nitrogen oxide in exhaled air [12].

Currently, there is no evidence that asthma in athletes is different from asthma in non-athletes. However, MK IOC and WADA restricts the use of certain drugs and doses in the treatment of asthma [12].

For the prevention of attacks of bronchospasm in athletes beta-2-agonists are commonly used, and for several decades the question is debated whether they cause the improved performance in athletes as according to the World Anti–Doping Agency Olympic athletes with the diagnosis of asthma in the last two Olympics won more medals than their fellow non-asthmatics.

At the present time directives WADA [25] athletes who have confirmed diagnosis of EIB permitted inhaled salbutamol (maximum 1600 micrograms over 24 hours), formoterol (maximum dose 54 micrograms over 24 hours) and salmeterol in accordance with the manufacturer's recommendations in the therapeutic dose [7].

Exercise-induced laryngeal obstruction (EILO), formerly known as vocal dysfunction (VCD), is a major simulators asthma and EIV. Although the term VCD covers more prominent in the scientific literature and is still in use, a recent consensus statement declares that EILO is more appropriate and more accurate umbrella term to represent conditions that cause narrowing of the larynx during exercise [10; 23].

EILO is paradoxically manifested by sudden constriction of the glottis during inspiration, and rarely at expiration, during exercise and immediately the development of dyspnea and inspiratory stridor, voice changes and heaviness in the chest that can lead to hypoxia and low efficiency [9]. In professional athletes EILO is a common cause of laryngeal obstruction during exercise. The prevalence of this disease among healthy population is about 5 % [22] athletes – from 35 % to 70 % [17].

The exact etiology of EILO is unknown; However, a variety of factors as Laryngeal hyperreactivity, guttural stimuli and psychogenic rare neurological disease are possible and recognized as the main causes of the dysfunction. In some cases, gastroesophageal reflux (GER) is a trigger in the development EILO [3]. The majority of cases EILO (> 80 %) is found in female athletes and the athletes who participate in outdoor sports and are often mistakenly classified as asthma [25].

Despite the fact that the EIV and EILO can exist separately, they often accompany each other. During numerous studies have shown that about one-third to half of the patients also had EIB [5], EILO and asthma – 6 % [12]. However, this does not mean that they are dependent on each other, as in EILO shortness of breath originates from the larynx, while EIB signs of laryngeal dysfunction there [13].

Accurate diagnosis of asthma, EIB and EILO requires objective testing. EILO is best diagnosed by direct visualisation (endoscopy) larynx. Spirometry is little value in the diagnosis EILO, as indicators such as reduced forced expiratory volume in 1 second and forced vital capacity, but should not be used as a primary diagnostic test for EILO because of low sensitivity. In some cases, clinical data can be differentiated states, usually manifested through EIV 5–20 minutes after exercise, while EILO evident during exercise and usually passes within 5 min after exercise.

Currently, surgery [24] that is used to strengthen the vocal cords, respiratory muscle training, speech therapy, psychotherapy, hypnosis is not yet as effective if wanted, so further studies are needed to determine how to optimize the effectiveness of measures at EILO [17].

Respiratory tract infections, including upper respiratory tracts (URTI), are very common in the general population and can affect people of different ages who are immunocompromised. We know that 75–80 % of all acute diseases in the US population due to respiratory diseases, 80 % are caused by viral infections of the respiratory tract diseases in average 3–6 per person per year. Athletes are no the exception. Symptoms that indicate the presence of URTI, ranged from 30 to 40 % of the complaints of professional athletes in the sports and medical clinics [6], especially in athletes runners, cyclists, skiers, swimmers, rowers, as well as tennis players and gymnasts [13].

Rhinoviruses, adenoviruses and para-influenza viruses often cause URTI in athletes. However, a small number of scientific works that have received actual evidence of an infectious agent in athletes with URTI [4; 7]. At least 70 % of cases were not identified pathogen and disease proceeded shorter in duration and less manifest.

It is known that exercise can cause significant changes in immunological parameters, including temporary immunosuppression (change in the number and activity of neutrophils, lymphocytes, macrophages and cytokine secretion, decreased activity of natural killer cells). Results of the study R. Paiange [19] showed that a significant physical activity leads to immunosuppression, which is most pronounced in the first hours after exercise. There is even a term J-curve («open window») when marked sensitivity to viral and bacterial infections. But it should be noted that despite numerous studies, a clear link between altered immune parameters and URTI is not documentary confirmed.

The study of the cellular structure showed an increase in the number of neutrophils, epithelial cells swimmers, skiers and hockey that may be a direct result of endurance training, as they are in the off-season. In contrast, the increase in eosinophils and lymphocytes, are probably due to the influence of environmental factors, such as chlorine or dry swimmers and skiers in the cold air. [6] Mixed (eosinophilic and neutrophilic) airway inflammation is found in hockey, as these athletes are chronically exposed to cold and dry air and oxides of carbon and nitrogen [4].

Fortunately, in most cases, these inflammatory cells exhibit a rather low level of adhesion, explaining why airway inflammation can occur in athletes erased, despite numerous inflammatory cellular elements. Recently, there is growing evidence that lifestyle factors, difficulties in overcoming everyday stress, the impact of food because their own diet and dietary supplements in a position to influence the immune response in athletes during intense exercise [9; 15; 24]. The concept of inflammation without infection in athletes requires further study.

Recent results [25] challenge the early doctrine that exercise influence the incidence of URTI.

Highly skilled athletes with recurrent URTI should undergo a thorough clinical examination to establish the basic factors of airway inflammation. Perhaps there is a genetic predisposition to the pro–inflammatory response disregulation and anti-inflammatory cytokines in response to intense exercise as a possible mechanism of airway inflammation.

Identifying athletes with an increased risk of relapse URTI is essential to prescribe preventive measures. Monitoring speed secretion and salivary IgA concentration drop can identify athletes at increased risk of the disease [13; 21].

Rhinitis is very common in athletes, the prevalence of which is> 30 % and swimmers, this figure could reach 74 % and may have a negative impact on athletic performance, as well as intense exercise requiring nasal breathing, in order to effectively meet the growing demand for oxygen [18].

Most athletes rhinitis is associated with an allergic component, so their condition worsens in the presence of specific environmental conditions; the impact of allergens in the air, inhaling irritants (O3, particulate matter and chlorination byproducts), or the influence of cold dry air [19; 22].

Cough is very common for the sportsmen, especially those who are engaged in winter sports [17]. In cross-country racers prevalence of this symptom can reach 86 %, while the cough is marked as the most common respiratory symptom [20] in athletes. Despite the fact that the cough is often associated with bronchospasm, as a result of physical activity, more than half of the athletes without evidence of bronchospasm reported the presence of cough due to physical stress [8; 22].

Along with asthma, any of the following factors can become a cause of coughing during or after exercise, rhinitis, sinusitis, laryngitis, respiratory irritants sensitising effect [8]. In each case, the symptom should be verified.

Subclinical pulmonary oedema. Arterial hypoxemia as a result of exercise (EIAH) is common in highly skilled athletes who train for endurance, especially in young athletes (50 % or more). [20] This gas exchange occurs violations of varying degrees. The result is EIAH insufficient supply of oxygen to working muscles, which may limit their performance. Mechanisms of this condition are not fully known, one of the possible – the development of high pressure in the lungs, which is able to injure the alveolar–capillary membrane. Clinical manifestations EIAH often occur in divers and swimmers, as well as marathon runners, triathletes [5;17; 23].

**Conclusions.** The prevalence of airway dysfunction among skilled athletes is much greater than in the normal population. Determining risk factors are atopy, fan needs of the sport and training environment.

Despite numerous studies in this area a lot of directions are to be clarified: not fully understood mechanisms of AHR during exercise for the sportsmen without atopy and clinical manifestations of the disease; causes «infection» of the upper respiratory tract, as well as preventive measures.

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