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Review article

ASTHMA AMONG ELITE ATHLETES, MECHANISM OF OCCURENCE AND IMPACT ON RESPIRATORY PARAMETERS: A REVIEW OF LITERATURE

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Abstract: **Introduction:** It is generally accepted that physical activity benefits every person but athletes diagnosed with asthma face various challenges during their training to keep the symptoms of the disease under control. Prolonged exposure to agents in the environment in which athletes train favors the development of permanent changes in the airways. Their action leads to permanent hyper reactivity with development of an inflammatory response and the release of mediators (IL-8, leucotriens, eicosanoids) that lead to damage epithelial cells with breaking connection between them and consequent dysfunction of the respiratory system. This condition is called exercise-induced asthma (EIA). This fact is especially important for athletes who have long endurance training. The best way to check the condition of breathing system is with a diagnostic method which is the „ gold" standard- spirometry.

Aim: The point of this systematic review is to get closer the mechanism occurrence of EIA/(exercise induced bronchoconstriction)-EIB, prevalence and incidence of EIA/EIB, changes of pulmonary function and quality of life in elite athletes. We searched papers from PubMed and Cochrane database using keywords: 'exercise-induced asthma', 'athletes', 'spirometry', 'bronchoconstriction', 'bronchospasm', 'physical activity', 'physical training', 'prevalence', 'incidence'. We have studied 48 scientific papers in total. **Conclusion:** The prevalence of asthma among elite athletes, especially endurance athletes is higher than in general population. The explanation of this phenomenon is related to the whole mechanism of occurrence, it is still insufficiently clarified, but one thing is for sure that with good disease control athletes can play and compete undisturbed for many years.

Keywords: exercise-induced asthma, elite athletes, mechanism of occurrence, spirometry, prevalence.

INTRODUCTION

Over the years, the definition of asthma has changed and supplemented with new knowledge. Nowadays, The National Institute of Health Guidelines of Asthma defined asthma like chronic inflammatory disturbance of the airways where macrophages, T-lymphocytes, mast cells, neutrophils, eosinophils and their elements have notable role in the occurrence of this disease (1). According to data WHO around 235 million people have diagnosed of asthma. Daily physical activity is recommended for all individuals but athletes with asthma confront special challenges in managing their disease while exercise (2). According to some data, top athletes had 17% prevalence of asthma, 10% of them used asthma drugs, which is almost three times higher than in general population which took participation in the research (3).When we talk about asthma among athletes, the most researchers think about exercise-induced asthma (EIA) or exercise-induced bronchoconstriction (EIB). Exercise-induced bronchoconstriction is manifestation of airway hyper responsivness (AHR) and is defined like temporarily airway obstruction and fall forced expiratory volume in first second (FEV1) after training for at least 10% of baseline (4). The clinical picture of EIA/ EIB is presented by coughing, wheezing, shortness of breath or chest tightness for an average of 5-30 minutes after exercise (5). According to

some Swiss guidelines the diagnosis of asthma is based on: history of respiratory system, confirmed variable expiratory airflow limitation, positive bronchodilatator reversibility test, excessive variability in twice daily PEF over two weeks, significant increase in lung function after four weeks of anti- inflammatory treatment, positive exercise challenge test and positive bronchial challenge test.

The objective of this handwriting is to ensure a concise overview of the effects of exercise on development of EIA/EIB, prevalence and incidence, their effects on lung function and quality of life at elite athletes.

MATERIAL AND METHODS

We selected substantial studies from databases of PubMed and Cochrane. The next keywords/ Mesh terms were used: 'exercise-induced asthma', 'athletes', 'spirometry', 'bronchoconstriction', 'physical activity', 'physical training', 'prevalence', 'incidence'. Headline, abstracts and full-text articles of possibility useful studies were independently checked by three researches. The reference lists of articles were scrutinized for detecting studies which were not grabbed by the electronic search. The study was conducted used literature published up to February, 2020. We searched, in detail, 48 scientific research papers.

Effects of exercise on development of asthma

How the literature explained the onset of EIA/EIB? The literature provides data for two type of mechanism of emergence EIA/EIB, *osmolar* and *vascular* hypotesis. Common to these two hypotheses is that they lead to increased ventilation throughout physical activity which leads to lose of water and heat during breathing. During water loss there is an increase in extracellular fluid osmolarity, that covers bronchial mucose, which leads to stimulation of cells to secrete fluid in extracellular environment leading to their shrinkage. This process is crucial in relishing the mediators of inflammation and consequently causing the contraction of the smooth muscles of the bronchial wall (6). The vascular hypothesis involves reheating the airways after cooling them. Throughout normal tidal volume the nose functions like rebreathing organ which warming up to 37,8° C and humidifying inspired air. By intensifying physical activities, it intensifies and ventilates, whereby nasal breathing stops and ventilation through the mouth rises, which leads to the loss of the heat and water through the expiration, also intensive physical activity induced releasing of growth hormone (GH) especially in water polo players (7, 8). Airway cooling causes the vagal parasympathetic reflex to be triggered thereby causing the airway narrow (9). Toward to neural theories, sensory nerves can be stimulated by osmotic stress and dry air causing hyperpnea releasing eicosanoids which activate sensory nerves (10). Prostaglandin D2 (PDG2) release from mast cells also stimulate sensory nerves across DP1 receptors (11). Increase in CysLTs and neurokin A is linked to bronchoconstriction. Also production of MUC5AC enclose the airway obstruction after exercise in patients with EIB (12). According to one study which scrutinized parasympathetic activity in athletes, correlation between parasympathetic activity and PD_{20met} depends on the type of sports (especially endurance sports, like swimming) and may be influenced by the training environment or specificity of training. In addition to osmotic and vascular theory, today's researches believe that oxidative stress is key to the development of bronchoconstriction because it can make cellular damage by oxidize membrane lipids, nuclear acid and proteins which cause the release of inflammatory cells (13). According to some authors, in the USA, ozone, particulate matter (PM) and trichloramines in swimming pools are the biggest pollutions to witch athletes are exposed during training. These pollutions increase the oxidative stress provokes airway inflammation and decrease lung function, especially in cold weather endurance athletes, swimmers and ice rink athletes (14). Expose to different allergens, PM, pollutants, cold and dry air, their inhalation leads to damage epithelial cells breaking the connections between them and making inflammation (15). This process resulting by relief markers of inflammation: Clara Cell protein 16 (marker of epithelial damage) and in sputum rising of: leukotriens and IL-8 after exercise (16). Some studies found that athletes like skiers and swimmers have bigger chance to develop some respiratory diseases, including asthma. Swimmers are exposed to chlorine, skiers train in dry air environment conditions. Exposing to this type of conditions, long time, it can cause epithelial damage, inflammation and finally remodeling airways like in asthma conditions (17).

Incidence and prevalence of EIA/EIB

The prevalence of EIA/EIB among elite athletes is high especially among durability athletes. Incidence testing is less prevalent among researches. One Swedish research showed that incidence of asthma diagnosed by physician was 61.2 per 1000 person-years, more common to the female population, in those with a familial predisposition to asthma and in all those whom wheezing is the most common symptom (18). With a prevalence of about 8%, asthma is the most represented chronic disorder that occurs in Olympians, especially those who play endurance sport (19). Some data

have shown that intense physical activity in Olympians leads to an increase in the number of asthma suffers, rises bronchial hyperactivity, leads to an increase in respiratory infections and impaired immune response. A large study conducted on 659 Italian Olympians who participated in the Summer and Winter Olympics in the period from 2000. to 2012. showed the following data: the number of asthma athletes who participated in the Olympic games in Sidney in 2000. was 11.3%, and in Beijing in 2008. it was 17.2%. The total prevalence for the examined period was 14.7% (20). There is also a higher prevalence of cross country skiers compared to general population, 23% of them have been diagnosed with asthma and 25% use asthma medications. This is almost twice as much as in the examined, general population (21). In relation to athletes who train endurance, some elite athletes evolved asthma or air-hyper responsive (AHR) late in their sports careers. A key factor was the quality of the inhaled air, which may be detrimental but not observed in athletes in every Olympic discipline eg. the use of â2 adrenoceptor agonists has been reported in 10% of rowers (19).

Lung function

Spiro metric examination of lung function provides an insight into the differences in the examined parameters in athletes who compete in different disciplines. Spirometry results, in athletes who examine, are most often described by comparing the following parameters: vital capacity (VC), forced expiratory volume in 1sc (FEV1), forced vital capacity (FVC), relationship FEV1/FVC, peak expiratory flow (PEF) and maximum voluntary ventilation (MVV) (22,23). FEV1 is consider to be a priority indicator of pulmonary function while PEF is less reproducible and refined (24). One study confirmed that fact, measuring FEV1 i PEF among athletes and control group and made conclusion that FEV1 are changeable in exercise training while the values of PEF did not have significant role in both of testing group (25). Constant physical activity during which endurance exercises are emphasized leads to permanent changes in spirometry parameters. This emphasizes the need to consider the development of different breathing patterns in different sports (26). According one study the elite athletes showed the significance in spirometry results. They discovered that the values of FVC, FEV1, MVV and VC were higher in water polo players then the other sports, the value of PEF was higher in basketball player than in handball player (27). That athletes who play endurance sports have significant changes in spirometry parameters is also shown by a study where swimmers recorded higher values of VC, FEV1, FVC, FEV1/FVC when compared to the parameters of football players and control group (28). Contrary to the above, by searching the literature, data can be obtained that there was no significant difference in spirometric evaluation between aerobic, anaerobic and control group. Diffusing capacity for carbon monoxide (DLCO) like the most valuable clinical test for the pulmonary function comparing with transfer coefficient for carbon monoxide (KCO) did not showed the statistical difference between mentioned groups (29). In one study, they compared respiratory parameters of aerobic and anaerobic athletes and control group with values of maxima oxygen consumption (VO2max) and made conclusion that there were no statistical difference between compared groups. Their conclusion was that physical activity improves respiratory function and VO2max, especially the aerobic type of training (30). Since it is hypertension the most common disorders of cardiovascular system, some authors have examined the effect of high blood pressure on exercise capacity. Their results showed that during the exercise there is a decrease in maximal oxygen consumption (VO2max), heart rate reserve (HRR) and ventilatory anaerobic threshold (VAT) in groups of sportsmen with high normal blood pressure (HNBP) and in hypertensives after adjustment of ages, body fat lining and type of sports activity (31).

Quality of life

Researchers believe in fact that asthmatics tolerate physical activity well and no study has shown otherwise, which could be proven in reached enormous success and playing elite sports (32). The quality of life at elite and endurance athletes depends on marginal performance benefits to reach the highest possible competitive positions. With certain pharmacological and non-pharmacological treatments, symptoms that would interfere with the performance of athletes can be prevented and treated, as well as reduced mortality and morbidity rates (15).

CONCLUSION

The prevalence of asthma among elite athletes, and especially those involved in endurance sports (water polo, swimming) is significantly higher than in the general population. Constant exposure to agents in environments where athletes exercise throughout frequent training and their inhalation leads to hyper reactivity of the respiratory mucosa which is accompanied by frequent inflammation and disruption of the structure of the bronchial tree. The entire pathophysiological mechanism is reflected in changes in spirometry parameters that are significantly higher among endurance athletes. The mechanism of EIA is significantly more complex and still insufficiently clarified. In the future, more researches should be conducted related to the

mechanism of occurrence, monitoring of spirometry parameters and quality of life of athletes during their careers and after that, in retirement.

Abbreviations

EIA — exercise-induced asthma
EIB — exercise induced bronchoconstriction
AHR — airway hyper responsivness
FEV1 — forced expiratory volume in first second
PEF — peak expiratory flow
VC — vital capacity
FVC — forced vital capacity
MVV — maximum voluntary ventilation

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Sažetak

ASTMA KOD VRHUNSKIH SPORTISTA; MEHANIZAM NASTANKA I UTICAJ NA DISAJNU FUNKCIJU - PREGLED LITERATURE

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Uvod: Opšte je prihvaćen stav da je fizička aktivnost korisna svakom pojedincu, ali sportisti sa dijagnostikovanom astmom se suočavaju sa raznim izazovima tokom treniranja da bi održali simptome pod kontrolom. Dugotrajno izlaganje faktorima iz okruženja u kom treniraju dovodi do trajnih promena na disajnim putevima. Njihovim dugotrajnim delovanjem dolazi do hiperreaktivnosti disajnih puteva sa posledičnim izazivanjem zapaljenskog odgovora i oslobađanjem medijatora zapaljenja (IL-8, leukotrieni, eikosanoidi) koji dovode do oštećenja epitelnih ćelija, izazivajući prekid konekcija među njima, sa posledičnim razvojem disfunkcije respiratornog sistema. Ovo stanje se naziva naporom izazvana astma. Ova činjenica je posebno važna kod sportista koji se bave sportovima izdržljivosti. Spirometrija, kao suverena metoda, predstavlja „zlatni standard" za procenu funkcije respiratornog sistema. Cilj naše studije je bio da razjasnimo mehanizam nastanka vežbama izazvane astme, njenu prevalencu i incidencu kod sportista, posledice tih vežbi na respiratorni sistem i kvalitet života sportista sa astmom. Pretražili smo radove na Pubmed-u i Kohranovoj bazi koristeći sledeće reči: 'naporom izazvana astma', 'sportisti', 'spirometrija', 'bronhokonstrikcija', 'fizička aktivnost', 'trening', 'prevalenca', 'incidenca'. Detaljno smo proučili 48 naučno-istraživačkih radova. **Zaključak:** Prevalenca astme među sportistima, posebno onima koji se bave sportovima izdržljivosti, značajno je viša nego u opštoj populaciji. Objašnjenje ove pojave se vezuje za mehanizam nastanka, koji je još uvek nedovoljno razjašnjen, ali je zasigurno da dobrom kontrolom bolesti sportisti mogu neometano da treniraju i da se takmiče dugi niz godina.

Ključne reči: astma izazvana naporom, vrhunski sportisti, mehanizam nastanka, spirometrija, prevalenca.

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