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EXERCISE INDUCED ASTHMA IN ATHLETES AND ITS MANAGEMENT- A REVIEW

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ABSTRACT:

Asthma, a globally prevalent respiratory condition, involves chronic airway inflammation and variable expiratory airflow limitation. Among elite athletes, respiratory conditions are notably common, affecting 20% to 70% across specific sports. Exercise-induced bronchoconstriction (EIB) is a frequent issue, impacting performance. The prevalence varies based on sport, training, and genetics. Although exercise triggers asthma, paradoxically, it can also enhance pulmonary function. Athletes' asthma phenotypes differ, posing challenges in management. Unique aspects include heightened airway sensitivity, allergen exposure, pollutants, and temperature variations. This review delves into EIB in athletes, covering pathogenesis, diagnosis, and treatment. EIB's pathogenesis involves complex interactions, including airway dehydration and cooling. Airway inflammation and hyper-responsiveness are common. Elite athletes show distinct inflammatory responses influenced by sport, training, and environment. Certain sports, like swimming, pose higher EIB risks, with chlorine exposure in pools being a notable factor. Diagnosing EIB in athletes requires objective testing, as baseline lung function tests may yield normal results. Exercise and bronchoprovocation tests provide reliable diagnoses. Spirometry and bronchodilation tests are standard, but emphasis is shifting toward provocation tests. Despite challenges, optimal diagnosis is crucial for effective management, leading to improved performance and quality of life. Managing EIB aligns with general principles for symptom control, prevention, and reducing complications. Non-pharmacological approaches, trigger avoidance, and warming up are essential. Inhaled corticosteroids (ICS) are key in asthma therapy for athletes, discouraging sole use of short-acting beta agonists. Mast cell stabilizing agents (MCSA) and leukotriene receptor antagonists (LTRA) are likely options. Optimal management enhances athletes' quality of life and allows effective pursuit of competitive sports.

KEY WORDS: Asthma; Exercise-Induced Bronchospasm; Athletes

I.INTRODUCTION:

Asthma, marked by chronic airway inflammation and variable expiratory airflow limitation, affects around 339 million people globally [1]. Athletes, especially at elite levels, show higher respiratory condition prevalence, including exercise-induced bronchoconstriction (EIB), ranging from 20% to 70% in specific sports. Factors like sport type, training, and genetics influence this prevalence [2]. Olympic athletes and those in endurance sports face higher asthma rates (15–30%). The term “EIA” now distinguishes between EIB with asthma (EIBA) and EIB without asthma (EIBwA) [3]. Exercise, a common asthma trigger, exacerbates symptoms but paradoxically improves overall health. Regular exercise benefits asthma symptoms, yet its impact on EIB is less understood. EIB can lead to avoidance of physical activity, affecting up to 90% of asthma patients [4]. While assumed to impact athletic performance, evidence is inconclusive, possibly due to study design and varied performance determinants. Early detection, confirmed through exercise lung function assessments, and appropriate treatment enhance EIB individuals’ quality of life, enabling participation in elite sports [5]. Athletes’

asthma phenotypes vary, influencing responses to medications and challenges in management. Heightened airway sensitivity in athletes makes them more susceptible to environmental triggers, complicating asthma symptoms and management [6].

II.CAUSES AND TRIGGERS OF EIB IN ATHLETES:

The pathogenesis of exercise-induced bronchoconstriction (EIB) in athletes is intricate, influenced by factors such as sport type, training environment, genetics, and individual sensitivities. Physiological and environmental interplays contribute, with variations between EIB with asthma (EIBA) and EIB without asthma (EIBwA) [7].

- **BRONCHOCONSTRICTION DURING EXERCISE**: EIB in athletes results from increased ventilation during intense exercise, leading to airway cooling and dehydration [8]. Osmotic and thermal theories explain the mechanisms, involving hyperosmolar airway surface liquid and vasoconstriction followed by reactive hyperemia [9].
- **AIRWAY INFLAMMATION**: Both EIBA and EIBwA involve airway inflammation triggered by exercise, especially in challenging conditions. Neutrophilic inflammation is linked to hyperpnea, distinct from asthmatic eosinophilic inflammation. Elite athletes exhibit elevated inflammatory markers not consistently responsive to inhaled steroids [10].
- **AIRWAY HYPER-RESPONSIVENESS**: Athletes with EIBA often display heightened airway sensitivity due to genetic factors and exposure to irritants. Exercise intensity, duration, and training regimen influence bronchial symptoms, airway hyper-responsiveness, and asthma development [11].
- **ENVIRONMENTAL FACTORS**: Cold dry air, allergens, pollutants, and temperature fluctuations significantly impact EIBA in athletes. Swimming, once favored for its humid air, now poses an elevated risk of EIB. Chlorinated pools and repeated hyperventilation challenges correlate with a high prevalence of asthma and EIBwA [12].
- **IMMUNE SYSTEM INVOLVEMENT**: Athletes may experience immune responses contributing to EIBA, including allergies or allergic asthma triggered by exercise-induced allergen exposure [13].
- **LUNG FUNCTION CHANGES**: Rapid deep breathing during exercise alters lung function, particularly in individuals with EIBA, resulting in decreased expiratory flow rates and increased airway resistance [14].
- **INDIVIDUAL VARIATION**: Severity and presentation of EIBA vary among athletes, with some experiencing mild symptoms not significantly affecting performance, while others struggle with more severe bronchoconstriction. Understanding condition-specific triggers is crucial for tailored treatment approaches [15].

III.DIAGNOSIS OF EIA IN ATHLETES

The diagnosis of exercise-induced bronchoconstriction (EIB) in athletes is crucial for their performance and overall health. Athletes often present normal lung function parameters, posing a challenge for accurate diagnosis. A comprehensive approach involving multiple tests is necessary [16].

- **SPIROMETRY AND BRONCHODILATION TEST**: Spirometry, measuring forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC), is a traditional diagnostic tool [17]. A positive response, exceeding 10% of the predicted value, indicates bronchodilator responsiveness. Limitations exist in comparing pre- and post-bronchodilator measurements [18].
- **PROVOCATION TESTS**: Direct and indirect bronchoprovocation challenges help assess bronchial hyper-reactivity (BHR). Direct challenges, like methacholine testing, are accurate for EIB with asthma (EIBA), while indirect challenges, including exercise and eucapnic voluntary hyperpnea (EVH), are considered precise for EIB without asthma (EIBwA). Exercise tests, with a decline in FEV1 of 10% or more, are effective, but some experts suggest a more stringent threshold [19,20].
- **EXERCISE CHALLENGE TEST (ECT)**: ECTs induce EIB by high ventilation, maintaining controlled temperature and humidity. Sport-specific ECTs are preferable in elite athletes, but variability exists, and no test fully replicates real-world stressors. EVH, requiring participants to breathe specific air, is a promising alternative, diagnosing EIB with a 10% FEV1 reduction [21,22].
- **INDIRECT CHALLENGES**: Exercise, EVH, inhaled mannitol, hypertonic saline, and AMP tests demonstrate effectiveness in detecting EIB in elite athletes, stimulating inflammatory cells [23]. Although promising, standardized protocols for these tests are inconsistent, potentially leading to false-negative results. Fractional exhaled nitric oxide (FeNO) offers good specificity but should not substitute for bronchial provocation testing due to limitations in sensitivity and predictive values. In summary, a combination of objective tests is essential for an accurate diagnosis of EIB in athletes, considering their unique physiological demands and potential variations in airway responses [24,25,26].

IV.MANAGEMENT OF EIB IN ATHLETES:

The prevalence of exercise-induced bronchoconstriction (EIB) is higher in competitive athletes, particularly those in endurance sports like swimming and winter sports [27]. Medication use is restricted in athletes by anti-doping agencies, posing a challenge for clinicians [28]. Treatment should adhere to general guidelines for symptom control, prevention, and comorbidity management [29].

MANAGEMENT PRINCIPLES:

- General guidelines for symptom control, exacerbation prevention, and avoiding airflow limitation apply to both athletes and non-athletes.

- Addressing comorbidities like gastroesophageal reflux disease (GERD), rhinitis, and sinusitis is crucial.

- Minimizing exposure to allergens is paramount in managing EIB effectively, and athletes need a comprehensive understanding of its impact [30].

UNIQUE ASPECTS FOR ATHLETES:

- Response to therapy may not always be optimal, and available medications cannot completely eliminate EIB.

- Athletes may exhibit unique characteristics in their inflammatory response, which can be less pronounced or blunted [31].

EXERCISE AND ASTHMA:

- Despite exercise triggering asthma symptoms, it is recommended as it reduces the minute ventilation required for a given exercise level.

- Choosing sports with fewer asthmatic triggers is advisable but not mandatory.

- EIB should not hinder participation or success in strenuous activities; strict adherence to the asthma action plan is crucial [32,33].

V.NON-PHARMACOLOGICAL TREATMENT:

- Trigger avoidance is a primary focus; protective measures and warming up before exercise are essential.

- Warming up for 10–15 minutes, incorporating calisthenics and stretching, with a heart rate goal of 50%–60%, can effectively reduce EIB.

- High-intensity interval and variable-intensity warm-ups are most reliable in reducing EIB [34,35].

VI.PHARMACOLOGICAL THERAPY:

- Asthma management involves non-pharmacological and pharmacological therapies.

- Inhaled corticosteroids (ICS) are used to reduce airway inflammation and prevent bronchoconstriction.

- ICS can be used as monotherapy or in combination with long-acting beta agonists (LABA).

In summary, managing EIB in athletes involves navigating the challenges of restricted medication use, emphasizing non-pharmacological approaches, and tailoring treatments to individual responses and athletic demands [36,37].

In athletes, inhaled corticosteroids (ICS) serve as the cornerstone of asthma therapy, though they are underused compared to inhaled β2 agonists [38]. Regular ICS use helps control asthma, improve lung function, and reduce airway responses to triggers, including exercise [39]. Consideration for ICS at a low daily dose arises when athletes need frequent as-needed β2 agonist use, including preventing exercise-induced bronchoconstriction, or if asthma limits exercise tolerance. If ICS alone doesn't achieve control, adding a long-acting inhaled β2 agonist may be considered [40].

Short-acting beta agonists (SABA) provide quick relief from exercise-induced bronchoconstriction (EIB) symptoms, but recent studies discourage their use as sole treatment. Instead, as-needed ICS/formoterol is recommended for adults and adolescents with mild asthma, emphasizing its superiority over as-needed SABA [41].

Chronic therapeutic options may include leukotriene receptor antagonists (LTRA) and mast cell stabilizing agents (MCSA). The use of short-acting anticholinergics for preventing exercise-induced bronchospasm is controversial, while evidence on long-acting anticholinergics is lacking [42].

In the context of doping regulations, it's crucial to note that certain medications may be prohibited by the World Anti-Doping Agency (WADA) if considered performance-enhancing or hazardous to health. However, athletes managing EIB are permitted to use inhaled corticosteroids (ICSs) and beta2 agonists within specified doses, provided they have documented therapeutic use prescriptions [43].

While this review provides insights into exercise-induced asthma (EIA) in athletes, acknowledging limitations, such as a non-systematic literature search, emphasizes the need for future research with rigorous methodologies to offer a more comprehensive understanding in the athletic community [44].

Main drug classes and their use in EIB.

Class	Name	Pharmacological Effect	Indication
Short-Acting Beta 2 Agonist	Salbutamol, Terbutaline	Quick relief from bronchoconstriction	Suitable for rapid relief but not intended for chronic usage unless the individual is concurrently on ICS or ICS/LABA maintenance therapy
Long-Acting Beta 2 Agonist	Formoterol, Vilanterol Olodaterol	Maintenance treatment for bronchoconstriction	Not intended for chronic usage, except when used in combination with ICS
Inhaled Corticosteroids (ICS)	Beclometasone, Budesonide, Fluticasone Furoate, Fluticasone Propionate	Reduces airway inflammation	Used as monotherapy or in combination and not intended forrapid relief
Short-Acting Muscarinic Agent	Ipratropium, Oxitropium	Provides bronchodilation	The use of these medications before exercise to prevent EIB is a subjectof controversy and remains an experimental approach
Long-Acting Anti-Muscarinic	Tiotropium, Umeclidinium, Glycopyrronium	Maintenance treatment for bronchoconstriction	There is no existing evidence regarding the use of this class of medications in athletes as monotherapy
ICS/LABA	Combination therapies that includeInhaled Corticosteroids (ICS) and Long-Acting Beta 2 Agonists (LABA)	Management of asthmain athletes	Used both as needed and for maintenance therapy and typically considered the first-line treatment for mild-to-moderate asthma
Biologic Agents	Omalizumab, Mepolizumab, Benralizumab, Dupilumab	Treatment for severe asthma in athletes and allergic reactions	Used in severe asthma, and they are not contraindicated in asthmatic athletes
Leukotriene Modifier	Montelukast, Zafirlukast, Pranlukast	Management of asthmain athletes	Reduces exercise-induced bronchoconstriction and provides protection against bronchoconstriction triggered by exposure to pollutants
Cromones	Cromolyn sodium	Prophylactic treatment for asthma, especially in athletes	Permitted for use by athletes butmay not be accessible in many market

CONCLUSION:

In summary, exercise-induced bronchoconstriction (EIB) poses a significant challenge for sports medicine and pulmonology professionals due to difficulties in detection and definitive diagnosis. Athletes benefit from therapies that enhance their physical activity, but the elusive nature of EIB, coupled with normal lung function in many cases, makes diagnosis challenging. A comprehensive approach involving multiple tests is necessary for accurate identification and management. While provocation tests like exercise or indirect challenges like eucapnic voluntary hyperpnea (EVH) provide precision, standardization issues affect test accuracy in athletes.

Regardless of its association with asthma or its absence, EIB management should align with general principles for symptom control, trigger minimization, addressing comorbidities, and educating athletes about effective EIB management. Clinicians in elite sports face a critical dilemma in balancing relief without using performance-enhancing medications.

Further research is needed to enhance diagnostic capabilities, including standardizing tests and integrating innovative methods like oscillometry. Exploring variations in inflammatory responses among athletes with EIB could lead to more personalized treatments. Investigating novel protocols and assessing the impact of emerging biological agents are crucial areas for future studies.

References:

[1] GBD 2019 Diseases and Injuries Collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019. *Lancet* **2020**, *396*, 1204–1222.

[2] Price, O.J.; Sewry, N.; Schwellnus, M.; Backer, V.; Reier-Nilsen, T.; Bougault, V.; Pedersen, L.; Chenuel, B.; Larsson, K.; Hull, J.H. Prevalence of lower airway dysfunction in athletes: A systematic review and meta-analysis by a subgroup of the IOC consensus group on 'acute respiratory illness in the athlete'. *Br. J. Sports Med.* **2021**, *56*, 213–222.

[3] Lund, T.; Pedersen, L.; Larsson, B.; Backer, V. Prevalence of asthma-like symptoms, asthma and its treatment in elite athletes.
Scand. J. Med. Sci. Sports **2008**, *19*, 174–178.

[4] Abbasi, A.; Vieira, R.D.P.; Northoff, H. Letter to the editor: The evidence of exercise-induced bronchoconstriction in endurance runners; genetic basis and gender differences. *Exerc. Immunol. Rev.* **2015**, *21*, 186–188.

[5] Jayasinghe, H.; Kopsaftis, Z.; Carson, K. Asthma Bronchiale and Exercise-Induced Bronchoconstriction. *Respiration* **2015**, *89*,505–512.

[6] Anderson, S.D.; Holzer, K. Exercise-induced asthma: Is it the right diagnosis in elite athletes? *J. Allergy Clin. Immunol.* **2000**, *106*, 419–428.

[7] Helenius, I.J.; Rytilä, P.; Metso, T.; Haahtela, T.; Venge, P.; Tikkanen, H.O. Respiratory symptoms, bronchial responsiveness, and cellular characteristics of induced sputum in elite swimmers. *Allergy* **1998**, *53*, 346–352.

[8] Karjalainen, E.M.; Laitinen, A.; Sue-Chu, M.; Altraja, A.; Bjermer, L.; Laitinen, L.A. Evidence of airway inflammation and remodeling in ski athletes with and without bronchial hyperresponsiveness to methacholine. *Am. J. Respir. Crit. Care Med.* **2000**, *161*, 2086–2091.

[9] Sue-Chu, M.; Karjalainen, E.M.; Laitinen, A.; Larsson, L.; Laitinen, L.A.; Bjermer, L. Placebo-controlled study of inhaled budesonide on indices of airway inflammation in bronchoalveolar lavage fluid and bronchial biopsies in cross-country skiers. *Respiration* **2000**, *67*, 417–425.

[10] Helenius, I.; Haahtela, T. Allergy and asthma in elite summer sport athletes. *J. Allergy Clin. Immunol.* **2000**, *106*, 444–452.

[11] Sue-Chu, M.; Karjalainen, E.-M.; Altraja, A.; Laitinen, A.; Laitinen, L.A.; Ss, A.B.N.; Larsson, L.; Bjermer, L. Lymphoid aggregates in endobronchial biopsies from young elite cross-country skiers. *Am. J. Respir. Crit. Care Med.* **1998**, *158*, 597–601.

[12] Sue-Chu, M.; Larsson, L.; Moen, T.; Rennard, S.I.; Bjermer, L. Bronchoscopy and bronchoalveolar lavage findings in cross-country skiers with and without 'ski asthma'. *Eur. Respir. J.* **1999**, *13*, 626–632.

[13] Hallstrand, T.S.; Moody, M.W.; Wurfel, M.M.; Schwartz, L.B.; Henderson, W.R.; Aitken, M.L. Inflammatory basis of exercise-induced bronchoconstriction. *Am. J. Respir. Crit. Care Med.* **2005**, *172*, 679–686.

[14] Verges, S.; Devouassoux, G.; Flore, P.; Rossini, E.; Fior-Gozlan, M.; Levy, P.; Wuyam, B. Bronchial hyperresponsiveness, airway inflammation, and airflow limitation in endurance athletes. *Chest* **2005**, *127*, 1935–1941.

[15] Helenius, I.; Rytilä, P.; Sarna, S.; Lumme, A.; Helenius, M.; Remes, V.; Haahtela, T. Effect of continuing or finishing high-level sports on airway inflammation, bronchial hyperresponsiveness, and asthma: A 5-year prospective follow-up study of 42 highly trained swimmers. *J. Allergy Clin. Immunol.* **2002**, *109*, 962–968.

[16] Anderson, S.D.; Kippelen, P. Exercise-induced bronchoconstriction: Pathogenesis. *Curr. Allergy Asthma Rep.* **2005**, *5*, 116–122.

[17] Carlsen, K.H.; Engh, G.; Mørk, M. Exercise-induced bronchoconstriction depends on exercise load. *Respir. Med.* **2000**, *94*, 750–755.

[18] Goodman, M.; Hays, S. Asthma and swimming: A meta-analysis. *J. Asthma* **2008**, *45*, 639–647.

[19] Andersson, M.; Hedman, L.; Nordberg, G.; Forsberg, B.; Eriksson, K.; Ronmark, E. Swimming pool attendance is

related toasthma among atopic school children: A population-based study. *Environ. Health* **2015**, *15*, 37.

[20] Bernard, A.; Nickmilder, M.; Voisin, C.; Sardella, A. Impact of chlorinated swimming pool attendance on the respiratory health ofadolescents. *Pediatrics* **2009**, *124*, 1110–1118.

[21] Atchley, T.J.; Smith, D.M. Exercise-induced bronchoconstriction in elite or endurance athletes: Pathogenesis and diagnostic considerations. *Ann. Allergy Asthma Immunol*. **2020**, *125*, 47–54.

[22] Weiler, J.M.; Hallstrand, T.S.; Parsons, J.P.; Randolph, C.; Silvers, W.S.; Storms, W.W.; Bronstone, A. Improving screening and diagnosis of exercise-induced bronchoconstriction: A call to action. *J. Allergy Clin. Immunol. Pract.* **2014**, *2*, 275–280.e7.

[23] Parsons, J.P.; Hallstrand, T.S.; Mastronarde, J.G.; Kaminsky, D.A.; Rundell, K.W.; Hull, J.H.; Storms, W.W.; Weiler, J.M.; Cheek, F.M.; Wilson, K.C.; et al. An official American Thoracic Society clinical practice guideline: Exercise-induced bronchoconstriction.*Am. J. Respir. Crit. Care Med.* **2013**, *187*, 1016–1027.

[24] Aggarwal, B.; Mulgirigama, A.; Berend, N. Exercise-induced bronchoconstriction: Prevalence, pathophysiology, patient impact, diagnosis and management. *NPJ Prim. Care Respir. Med.* **2018**, *28*, 31.

[25] Rundell, K.W.; Slee, J.B. Exercise and other indirect challenges to demonstrate asthma or exercise-induced bronchoconstriction in athletes. *J. Allergy Clin. Immunol.* **2008**, *122*, 238–246.

[26] Crapo, R.O.; Casaburi, R.; Coates, A.L.; Enright, P.L.; Hankinson, J.L.; Irvin, C.G.; MacIntyre, N.R.; McKay, R.T.; Wanger, J.S.; Anderson, S.D.; et al. Guidelines for methacholine and exercise challenge testing-1999. This official statement of the AmericanThoracic Society was adopted by the ATS Board of Directors, July 1999. *Am. J. Respir. Crit. Care Med.* **2000**, *161*, 309–329.

[27] Rundell, K.W.; Wilber, R.L.; Szmedra, L.; Jenkinson, D.M.; Mayers, L.B.; Im, J. Exercise-induced asthma screening of elite athletes: Field versus laboratory exercise challenge. *Med. Sci. Sports Exerc.* **2000**, *32*, 309–316.

[28] Anderson, S.D.; Pearlman, D.S.; Rundell, K.W.; Perry, C.P.; Boushey, H.; A Sorkness, C.; Nichols, S.; Weiler, J.M. Reproducibility of the airway response to an exercise protocol standardized for intensity, duration, and inspired air conditions, in subjects withsymptoms suggestive of asthma. *Respir. Res.* **2010**, *11*, 120.

[29] Anderson, S.D.; Schoeffel, R.E.; Follet, R.; Perry, C.P.; Daviskas, E.; Kendall, M. Sensitivity to heat and water loss at rest and during exercise in asthmatic patients. *Eur. J. Respir. Dis.* **1982**, *63*, 459–471.

[30] Fitch, K.D.; Sue-Chu, M.; Anderson, S.D.; Boulet, L.P.; Hancox, R.J.; McKenzie, D.C.; Ljungqvist, A. Asthma and the elite athlete: Summary of the International Olympic Committee's consensus conference, Lausanne, Switzerland, January 22–24, 2008. *J. Allergy Clin. Immunol.* **2008**, *122*, 254–260.e1–7.

[31] Dickinson, J.; Gowers, W.; Sturridge, S.; Williams, N.; Kippelen, P.; Simpson, A.; Jackson, A.; Hull, J.H.; Price, O.J. Fractional exhaled nitric oxide in the assessment of exercise-induced bronchoconstriction: A multicenter retrospective analysis of UK-based athletes. *Scand. J. Med. Sci. Sports* **2023**, *33*, 1221–1230.

[32] Miller, M.G.; Weiler, J.M.; Baker, R.; Collins, J.; D'Alonzo, G. National Athletic Trainers' Association position statement: Manage-ment of asthma in athletes. *J. Athl. Train.* **2005**, *40*, 224–245.

[33] Greiwe, J.; Cooke, A.; Nanda, A.; Epstein, S.Z.; Wasan, A.N.; Shepard, K.V.; Capao-Filipe, M.; Nish, A.; Rubin, M.; Gregory, K.L.; et al. Work Group Report: Perspectives in Diagnosis and Management of Exercise-Induced Bronchoconstriction in Athletes.*J. Allergy Clin. Immunol. Pract.* **2020**, *8*, 2542–2555.

[34] Parsons, J.P.; Mastronarde, J.G. Exercise-induced bronchoconstriction in athletes. *Chest* **2005**, *128*, 3966–3974.

[35] McCreanor, J.; Cullinan, P.; Nieuwenhuijsen, M.J.; Stewart-Evans, J.; Malliarou, E.; Jarup, L.; Harrington, R.; Svartengren, M.; Han,I.-K.; Ohman-Strickland, P.; et al. Respiratory effects of exposure to diesel traffic in persons with asthma. *N. Engl. J. Med.* **2007**,*357*, 2348–2358.

[36] Millqvist, E.; Bake, B.; Bengtsson, U.; Lowhagen, O. A breathing filter exchanging heat and moisture prevents asthma induced bycold air. *Allergy* **1995**, *50*, 225–228.

[37] Beuther, D.A.; Martin, R.J. Efficacy of a heat exchanger mask in cold exercise-induced asthma. *Chest* **2006**, *129*, 1188–1193.

[38] Elkins, M.R.; Brannan, J.D. Warm-up exercise can reduce exercise-induced bronchoconstriction. *Br. J. Sports Med.* **2012**, *47*,657–658.

[39] Boulet, L.P.; O'Byrne, P.M. Asthma and exercise-induced bronchoconstriction in athletes. *N. Engl. J. Med.* **2015**, *372*, 641–648.

[40] Dickinson, J.; Amirav, I.; Hostrup, M. Nonpharmacologic Strategies to Manage Exercise-Induced Bronchoconstriction. *Immunol.Allergy Clin. N. Am.* **2018**, *38*, 245–258.

[41] Papi, A.; Ferreira, D.S.; Agache, I.; Baraldi, E.; Beasley, R.; Brusselle, G.; Coleman, C.; Gaga, M.; Maria, C.; Rivera, G.; et al. European Respiratory Society short guidelines for the use of as-needed ICS/formoterol in mild asthma. *Eur. Respir. J.* **2023**, *62*,2300047.

[42] Bordeleau, M.; Turmel, J.; Boulet, L.P. Effects of ipratropium on exercise-induced cough in winter athletes: A hypothesis-generating study. *Physician Sportsmed.* **2014**, *42*, 7–13.

[43] Boaventura, L.C.; Araujo, A.C.; Martinez, J.B.; Vianna, E.O. Effects of ipratropium on exercise-induced bronchospasm.

[44] Cazzola, M.; Ora, J.; Rogliani, P.; Matera, M.G. Role of muscarinic antagonists in asthma therapy. *Expert Rev. Respir. Med.* **2017**, *11*,239–253.