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## **The influence of air pollution on asthma in athletes – a brief review of the literature**

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## Abstract

### Introduction and purpose

Air pollution, stemming from natural occurrences and human activities, significantly threatens global health, particularly impacting respiratory conditions like asthma. Air pollution substantially influences asthma exacerbation in athletes, a group particularly vulnerable due to their high physical activity levels and increased respiratory demands. The World Health Organization (WHO) reports that 90% of the global population breathes polluted air, with millions of deaths annually attributed to outdoor and household air pollution. Key pollutants, including particulate matter (PM), ground-level ozone (O<sub>3</sub>), sulfur dioxide (SO<sub>2</sub>), and nitrogen dioxide (NO<sub>2</sub>), play critical roles in asthma development and exacerbation.

### The State of Knowledge

Asthma, a chronic inflammatory disease influenced by genetic predisposition and environmental factors like air pollution, is characterized by airway hyperresponsiveness, obstruction, and chronic inflammation, leading to symptoms such as shortness of breath, coughing, wheezing, and chest tightness. Early-life exposure to pollutants significantly increases asthma risk, particularly for children near major roads or exposed to PM<sub>2.5</sub> and black carbon. Research highlights the link between air pollution exposure and asthma

development, with PM<sub>2.5</sub> exposure associated with increased asthma risk and pollutants like SO<sub>2</sub>, NO<sub>2</sub>, and O<sub>3</sub> exacerbating symptoms, especially in children due to their higher respiratory rates and greater air intake relative to body weight. Athletes inhaling air pollutants during exercise face increased airway inflammation, mucus production, and bronchospasm, worsening asthma symptoms like wheezing and shortness of breath. Exercise-induced bronchoconstriction (EIB) is aggravated by poor air quality, hindering performance. Chronic exposure decreases lung function, increasing reliance on medication and limiting outdoor training on polluted days.

### Summary

Effective asthma management amidst air pollution requires personal, community, and governmental measures. Patients should minimize exposure by wearing N95 masks and choosing low-traffic routes. Governments must monitor pollution, inform the public, and control emissions through alternative fuels and technologies. Adhering to WHO air quality guidelines could prevent many new asthma cases, emphasizing comprehensive air quality management's importance, especially among vulnerable populations like children.

Key words: asthma, air pollution, asthma exacerbation, asthma development

## **1. Introduction and purpose**

Air pollution stems from both natural occurrences and human activities, posing a significant threat to global health. The World Health Organization (WHO) reports that nine out of ten individuals globally breathe polluted air. Their 2018 report attributed 4.2 million deaths each year to outdoor air pollution and an additional 3.8 million deaths to indoor smoke exposure [1]. These pollutants can infiltrate the respiratory system, adversely affecting the development and severity of respiratory diseases like asthma.

Comprising a complex mix of particles and gases, air pollution includes several key pollutants regulated by the Environmental Protection Agency (EPA) through National Ambient Air Quality Standards. These pollutants are particulate matter (PM), ground-level ozone (O<sub>3</sub>), carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>), and nitrogen dioxide (NO<sub>2</sub>) [2]. Ground-level ozone is produced when nitrogen oxides and volatile organic compounds react under heat and sunlight. Particulate matter is classified by particle size: coarse particles (PM<sub>10</sub>) range from 2.5 to 10 micrometers, fine particles (PM<sub>2.5</sub>) range from 0.1 to 2.5 micrometers, and ultrafine particles (PM<sub>0.1</sub>) are smaller than 0.1 micrometers [2,3].

In 2019, 99% of the world's population lived in areas where air quality failed to meet WHO guidelines [3]. Key sources of air pollution include household combustion devices, vehicle emissions, industrial facilities, and forest fires. Beyond directly affecting respiratory health, air pollution also drives climate change, leading to higher environmental temperatures that can worsen respiratory conditions.

## **2. The state of knowledge**

### **2.1. The definition of asthma**

Asthma is a long-term inflammatory disease of the airways, marked by increased airway sensitivity (AHR), obstruction of the airways, and persistent inflammation and remodelling of the airways. These issues result in common symptoms like difficulty breathing, coughing, wheezing, and a feeling of tightness in the chest [4]. The development of asthma is influenced by several risk factors, such as genetic susceptibility, contact with allergens, and exposure to air pollution.

Asthma can be subdivided into several phenotypes, often based on age at onset and the type of inflammatory cells involved. For example, type 2-mediated early-onset asthma, which typically begins in childhood, is linked to allergies such as those to house dust mites [5]. This eosinophilic form of asthma usually responds well to inhaled corticosteroids (ICS) and can range in severity from mild to severe. In contrast, type 2-mediated late-onset nonallergic eosinophilic asthma is often severe and does not respond well to ICS treatment [6]. Additionally, Th1 and Th17 responses are believed to play a significant role in nontype 2 asthma, particularly in forms characterized by predominant neutrophilic inflammation [5,6].

Genetic factors have a substantial influence on asthma, as demonstrated by genome-wide association studies that pinpoint asthma-related loci throughout the genome. Beyond genetic predisposition, epigenetic alterations, including DNA methylation, chromatin remodeling, histone modifications, and noncoding RNAs, play a crucial role [7]. These epigenetic changes,

influenced by environmental exposures, significantly contribute to the development of asthma [7].

Air pollution exposure is a major risk factor for both the onset and worsening of inflammatory diseases in the lower airways, including asthma. Particulate matter (PM<sub>2.5</sub>), a primary component of air pollution, can penetrate deep into the bronchioles and alveoli, triggering inflammatory responses [8-11]. Outdoor sources of PM include mineral dust, pollen, vehicle exhaust, and heating combustion, while indoor sources include smoking, incense burning, vacuum cleaning, sanitary and hygienic sprays, clothing residues, friction, domestic animals, and cooking.

In addition to PM<sub>2.5</sub>, other major air pollutants related to asthma include noxious gases such as sulfur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), and ozone (O<sub>3</sub>) [9]. These pollutants contribute significantly to asthma pathogenesis and symptom exacerbation, underscoring the importance of addressing air quality to manage and prevent asthma effectively.

## **2.2 The development of asthma and air pollution**

The impact of air pollution exposure at various early life stages was examined in Project Viva [12]. The study found that children who lived near a major road at birth had a higher likelihood of developing asthma by ages 3 to 5, indicating that exposure to air pollutants at birth significantly influences early asthma development. However, this early exposure did not impact asthma development at ages 7 to 10. On the other hand, children who were exposed to black carbon or PM<sub>2.5</sub> between ages 0 to 5 had a greater risk of developing asthma by ages 3 to 5 compared to those exposed only during their first year of life. This suggests that continuous exposure from birth through the early years increases the likelihood of early-onset asthma. Additionally, the risk of developing asthma at ages 7 to 10 was higher for children living close to a major road during this later period [12].

Numerous studies have documented the epidemiological link between air pollution exposure and the development and exacerbation of asthma. One study found that extended exposure to PM<sub>2.5</sub> increased the risk of asthma in Chinese preschool children, with those living in suburban or rural areas being particularly vulnerable to PM<sub>2.5</sub> exposure [13]. Carlsten et al. investigated the relationship between traffic-related air pollutants (NO, NO<sub>2</sub>, black carbon, and PM<sub>2.5</sub>) at birth and the onset of asthma by age 7. They discovered that an interquartile range increase in PM<sub>2.5</sub> concentration at birth (4.1 µg/m<sup>3</sup>) was associated with a significantly higher risk of asthma in children [14]. In another study, Lavigne et al. conducted

a population-based cohort study in Ontario, Canada, identifying children who developed asthma before age 6. Their adjusted models indicated that higher outdoor PM<sub>2.5</sub> concentrations during childhood were linked to an increased incidence of childhood asthma [15].

### **2.3 The impact of air pollution on asthma exacerbation**

Exposure to air pollutants like PM<sub>2.5</sub>, O<sub>3</sub>, NO<sub>2</sub>, and SO<sub>2</sub> has been linked to worsening asthma symptoms, evidenced by increased hospitalization rates among asthma patients due to air pollution [16]. Previous research indicates that short-term exposure to PM<sub>2.5</sub> negatively affects asthma-related emergency department visits, particularly among children, a high-risk group, especially during periods of elevated PM<sub>2.5</sub> levels [17]. Another study on O<sub>3</sub>'s impact on asthma hospital admissions found a significant association between O<sub>3</sub> levels and asthma-related admissions, with children being the most susceptible. This suggests that children are especially vulnerable to asthma exacerbation from air pollution. Their unique anatomy and physiology, including faster breathing rates and higher air intake relative to body weight, make them more susceptible to poor air quality [18].

### **2.4 Outdoor Air Pollution and Asthma Management**

To mitigate the risks associated with outdoor air pollution, a range of personal, community, and governmental measures have been recommended. Educating patients to minimize their exposure to air pollutants is crucial for managing asthma. Effective strategies include wearing close-fitting N95 masks during high pollution levels, opting for active travel methods like walking or cycling instead of motorized transport, choosing routes with less traffic and more open spaces, keeping car windows closed, maintaining car air filtration systems, using internal circulation, and staying informed about local air pollution levels [19]. Publicly available online alerts about pollution peaks can help people avoid outdoor activities during periods of poor air quality, which can be incorporated into asthma action plans. Additionally, pollution peaks often coincide with seasonal aeroallergen exposure, exacerbating asthma outcomes [20]. Patients with asthma should ideally live at least 300 meters away from major roads to reduce pollutant exposure [21].

Governments play a vital role in monitoring air pollution, informing the public about high pollution risks, and implementing measures to control PM emissions. These measures include

considering alternative fuels like natural gas, utilizing fuel-cleaning methods such as coal washing, and adopting alternative production processes and technologies. For instance, a European pediatric study indicated that adhering to WHO air quality guidelines for PM<sub>2.5</sub> could prevent 11% of all new asthma cases, while the lowest pollution levels for NO<sub>2</sub> (1.5 µg/m<sup>3</sup>) and PM<sub>2.5</sub> (0.4 µg/m<sup>3</sup>) could prevent 23% and 33% of new cases, respectively [22].

## **2.5 The influence of air pollution on asthma in young athletes**

Athletes inhale these pollutants during training or competition, and the irritants can trigger a cascade of inflammatory responses, leading to airway constriction, increased mucus production, and bronchospasm. The increased breathing rate and depth during exercise result in a higher intake of air, and consequently, more pollutants enter the lungs. This heightened exposure can exacerbate asthma symptoms more intensely in athletes than in the general population. Symptoms such as wheezing, coughing, chest tightness, and shortness of breath can become more frequent and severe, disrupting training routines and competitive performance. Exercise-induced bronchoconstriction (EIB), which is common in athletes, is particularly sensitive to air quality [31,32]. Polluted air can aggravate EIB, making it harder for athletes to maintain optimal breathing and stamina. Moreover, chronic exposure to polluted air can lead to a decline in overall lung function, making asthma management more challenging. For athletes, optimal lung capacity and function are crucial for peak performance. Persistent exposure to air pollution can necessitate increased reliance on asthma medications, more frequent medical consultations, and potentially limiting outdoor activities on days with poor air quality. These limitations can hinder an athlete's ability to train effectively and compete at high levels [33].

## **3. Conclusions**

Air pollution, originating from both natural sources and human activities, poses a significant threat to global health, particularly impacting respiratory conditions like asthma. Key pollutants, including particulate matter (PM), ground-level ozone (O<sub>3</sub>), sulfur dioxide (SO<sub>2</sub>), and nitrogen dioxide (NO<sub>2</sub>), are linked to both the development and exacerbation of asthma. Studies indicate that early-life exposure to these pollutants significantly increases the risk of developing asthma in children, with continuous exposure from birth through early childhood being particularly detrimental.

Children are especially vulnerable to asthma exacerbation from air pollution due to their unique anatomy and physiology, which result in higher air intake relative to body weight [23-26]. Consequently, reducing air pollution exposure is crucial for managing and preventing asthma. Effective measures include personal strategies, such as wearing N95 masks, choosing low-traffic routes, and staying informed about air quality levels. Community and government interventions, such as urban planning for green spaces and stringent air quality monitoring, are also vital.

Governmental actions to control PM emissions, including the adoption of alternative fuels and production technologies, can significantly reduce the incidence of asthma [27-30]. Adhering to WHO air quality guidelines has the potential to prevent a substantial number of new asthma cases, emphasizing the importance of comprehensive air quality management in protecting public health, particularly among vulnerable populations like children.

To address these challenges, athletes and their support teams must be proactive in monitoring air quality. Utilizing local air quality indices and real-time pollution monitoring can help in planning training sessions and competitions to avoid peak pollution times. On days with high pollution levels, shifting to indoor training or using air purification systems can be effective strategies. Sports organizations and coaches have a critical role in providing guidance and resources to help athletes manage their asthma. Implementing comprehensive asthma management plans that include regular medical assessments, personalized medication plans, and strategies to minimize pollution exposure can ensure that athletes maintain their respiratory health and continue to excel in their sports.

### **Author's contribution**

Conceptualization, WM, and BR; methodology, WM, BR, and MP; software, ŁM, DB, ZC, BR, JO and BK; check, WM, MS and WK; formal analysis, WM, BK, JO, WK, ŁM, DB; investigation, ŁM, ZC, and BR; resources, WM, and BR; data curation, WM, ZC; writing - rough preparation, WM, WK, BK, MP, BR, JO; writing - review and editing, WM, BR, BK, MP, ŁM, MS, ZC, DB; visualization, MS, DB; supervision, WM and DB; project administration, WM, BR; All authors have read and agreed with the published version of the manuscript.



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