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Editorial

# Does Exercise Overcome Pollution? Why Physical Activity is Still Our Best Medicine

## ¿Supera el ejercicio a la contaminación? Por qué la actividad física sigue siendo nuestra mejor medicina

Lack of activity destroys the good condition of every human being, while movement and methodical physical exercise save it and preserve it." This quote highlights that 2400 years ago, Plato understood that sedentary lifestyles cause physical decay. Fortunately, his philosophy has become a foundational, though sometimes implicit, belief in modern health and social behavior, and it is widely validated by contemporary medical research linking exercise to enhanced medical condition and improved cognitive function.

Though, current global estimates show that 1 in 3 adults and 81% of adolescents do not get enough physical activity.[1] This has a special impact on patients with chronic respiratory diseases, in whom the therapeutic approach based on physical training has proven to be safe and highly effective in improving functioning and quality of life.[2] Promoting exercise among these vulnerable individuals is an obligation for the medical community responsible for their care.

However, in the 21st century, public health faces a profound physiological paradox. While physical inactivity is a critical risk factor for non-communicable diseases (NCDs),[1] ambient air pollution has emerged as the most potent environmental threat to global health. According to World Health Organization (WHO), approximately 90% of the world's population breathes air containing high levels of pollutants, with over 80% of urban residents exposed to poor air quality that exceeds WHO guidelines.[3] Air pollution is not a single factor, but a heterogeneous and dynamic mixture of compounds in gaseous, liquid, and solid phases that vary according to location, time of day, and weather conditions.

This reality forces a difficult question: ***do the benefits of staying active outweigh the risks of inhaling toxic air during exertion?***

### The physiological "cost" of moving in the city

To begin with, we can believe that the here and now of exercise in modern cities has become a double-edged sword. In light of current evidence, endurance exercise in environments with high exposure to traffic pollutants, such as fine particulate matter (PM) and gases, can have significant negative effects on cardiopulmonary health,[4–6] including increased levels of inflammation and oxidative stress, as well as worsening of symptoms (such as cough and chest tightness) and decreased respiratory function. Performance effects are noticeable, with a consistent decrease in peak oxygen consumption[5–8] and competition output.[4]

The risk lies in the fact that exercise acts as a multiplier for the inhaled dose of pollutants. To meet metabolic demands, subjects experience increased minute ventilation and a shift from nasal to oral breathing, which bypasses the body's natural filtration and allows particles to penetrate deeper into the airway epithelium.[4,8] The ability of gases to diffuse from the lung to the bloodstream (i.e., diffusing capacity) also growths as does the deposition fraction. During an exercise bout, the combination of a greater deposition fraction and total inhaled PM (due to higher VE′) results in a fourfold increase in the total number of UFP (ultrafine particulate matter) deposited in the airways during light exercise and a further doubling during high intensity exercise.[4]

Research indicates that the duration of effort is a critical factor for acute health effects. Exercise sessions lasting 120 min or more in conditions exceeding WHO thresholds are significantly more likely to result in reduced lung function ($FEV_1$) and increased airway inflammation.[8] Paradoxically, the influence of exercise intensity is less clear; some studies suggest that higher intensity may even play a protective role by inducing bronchodilation via endogenous catecholamines, which may partially mitigate the immediate effects of irritants like *DE (diesel exhaust)*.[9] Recent evidence shows that air pollution increases mortality risk by roughly 36%, but exercising in that same air still reduces the risk of death by 26% (compared to 31% in clean air).[10]

### COPD and asthma: vulnerable populations

Air pollution factors significantly impact both Chronic Obstructive Pulmonary Disease (COPD) and Asthma by hindering physical activity, reducing lung function, and triggering exacerbations.[11,12]

Since most physical activity takes place outdoors, it is important to understand how environmental threats affect physical activity levels in patients with COPD. For instance, a short-term exposure to traffic pollution (e.g., walking on a busy street) reduces the beneficial effects of physical activity, such as improved lung function.[12] Also, four days after exposure to peak pollution, COPD patients show fewer steps, less time in moderate-to-vigorous physical activity (MVPA), and increased sedentary time.[13]

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For asthma, elevated levels of *PM*, $O_3$, *CO*, $SO_2$, and $NO_2$ are directly linked to increased emergency department visits, hospitalizations, and higher mortality. Among the mechanisms, pollutants generate reactive oxygen species (ROS), causing lung injury and activating inflammatory pathways (Th2 and Th17 responses) that produce neutrophils and eosinophils. Pollutants like $O_3$ and $NO_2$ can bind to pollen grains, acting as adjuvants that increase their allergenic potential and amplifying the body's allergic response.[11]

Definitely, air pollution can trigger a "vicious circle of dyspnea and inactivity," where increased breathlessness leads patients with respiratory conditions to avoid exertion, resulting in physical deconditioning. To prevent this, the message must be clear: despite acute risks, the long-term benefits of exercise usually outweigh the harm from pollution.

## Strategic recommendations for safe practice

The solution isn't to stop moving, but to move more intelligently. To minimize risk, both individuals and healthcare professionals should adopt evidence-based strategies, such as[14,15]:

- limiting planned exercise to less than 60 min when air quality is poor;
- runners should prioritize early morning or late evening sessions to avoid peak traffic and high ozone levels;
- walking should be prioritized in urban green spaces or pedestrian streets away from high-density traffic;
- strength training results in a lower burden on the impaired ventilatory system compared with endurance training. Furthermore, it can be an effective indoor alternative on high-pollution days.
- using real-time air quality monitoring apps to choose routes with the lowest concentrations of pollutants.

To conclude, there is an urgent need for more rigorous and larger-scale research to fully understand the long-term impacts of urban exercise. As we move forward, the goal is to create an environment where the health of the general public and in turn, that of patients with chronic respiratory diseases, is protected by design, ensuring that every breath during exercise contributes to health rather than a risk.

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## Authors' contributions

PCR designed and wrote the manuscript. RRR contributed to the revision of the manuscript. All authors have read and approved the final version of the manuscript.

## Conflicts of interest

The authors declare that they have no conflicts of interest.

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