

“Where there's smoke, there's fire”: The impact of recent burnings in Brazil and their effects on air quality for outdoor physical exercise

“Onde há fumaça, há fogo”: O impacto das queimadas recentes no Brasil e seus efeitos na qualidade do ar para a prática de exercícios físicos ao ar livre

“Donde hay humo, hay fuego”: El impacto de los incendios recientes en Brasil y sus efectos en la calidad del aire para el ejercicio físico al aire libre

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Abstract

Brazil's alarming surge in wildfires in 2024 has led to a severe deterioration in air quality, particularly affecting the Amazon, Cerrado, and Pantanal biomes. The smoke, rich in fine particulate matter (PM_{2.5}), poses significant health threats, including respiratory and cardiovascular diseases, and has raised growing concerns about the safety of outdoor physical activity. Prolonged exposure to these pollutants can trigger systemic oxidative stress, airway irritation, and inflammation, further compromising health outcomes for individuals who exercise outdoors. The objective of this article is to outline strategies to mitigate these adverse effects and offer practical recommendations for exercising safely when ambient air quality is compromised. This article examines the complex balance between the proven benefits of physical activity and the hazards of exercising in polluted environments, while providing practical, evidence-based recommendations to mitigate risks. Suggested strategies include prioritizing indoor training spaces equipped with HEPA or MERV-13 filtration, adjusting workout timing, intensity, and duration according to air quality index, offering specific guidance for vulnerable populations (such as children, older adults, and individuals with asthma or heart disease), and adopting protective measures like N95 masks, hydration, and skin protection. These insights aim to guide safe exercise practices during periods of compromised air quality.

Keywords: Wildfires; Air Quality; Physical Exercise.

Resumo

O alarmante aumento das queimadas no Brasil em 2024 levou a uma grave deterioração da qualidade do ar, afetando especialmente os biomas Amazônia, Cerrado e Pantanal. A fumaça, rica em material particulado fino (PM_{2.5}), representa ameaças significativas à saúde, incluindo doenças respiratórias e cardiovasculares, e levantou crescentes preocupações quanto à segurança da prática de atividades físicas ao ar livre. A exposição prolongada a esses poluentes pode desencadear estresse oxidativo sistêmico, irritação das vias aéreas e inflamação, comprometendo ainda mais a saúde de indivíduos que se exercitam ao ar livre. O objetivo deste artigo é delinear estratégias para mitigar esses efeitos adversos e oferecer recomendações práticas para praticar exercícios com segurança quando a qualidade do ar ambiente estiver comprometida. Este artigo examina o complexo equilíbrio entre os benefícios comprovados da atividade física e os riscos de se exercitar em ambientes poluídos, ao mesmo tempo em que fornece recomendações práticas e baseadas em evidências para mitigar esses riscos. As estratégias sugeridas incluem priorizar espaços internos de treino equipados com filtragem HEPA ou MERV-13, ajustar o horário, a intensidade e a duração dos treinos conforme os níveis do IQA, oferecer orientações específicas para populações vulneráveis (como crianças, idosos e pessoas com asma ou doenças cardíacas) e adotar medidas de proteção, como máscaras N95, hidratação e cuidados com a pele. Essas orientações visam a guiar práticas seguras de exercício durante períodos de qualidade do ar comprometida.

Palavras-chave: Incêndios Florestais; Qualidade do Ar; Exercício Físico.

Resumen

El alarmante aumento de los incendios forestales en Brasil en 2024 ha provocado un grave deterioro de la calidad del aire, afectando especialmente a los biomas Amazonía, Cerrado y Pantanal. El humo, rico en material particulado fino (PM_{2.5}), representa amenazas significativas para la salud, incluyendo enfermedades respiratorias y cardiovasculares, y ha generado una creciente preocupación por la seguridad de la práctica de actividades físicas al aire libre. La exposición prolongada a estos contaminantes puede desencadenar estrés oxidativo sistémico, irritación de las vías respiratorias e inflamación, comprometiendo aún más la salud de las personas que se ejercitan al aire libre. El objetivo de este artículo es delinear estrategias para mitigar estos efectos adversos y ofrecer recomendaciones prácticas para ejercitarse de manera segura cuando la calidad del aire ambiente esté comprometida. Este artículo examina el complejo equilibrio entre los beneficios comprobados de la actividad física y los riesgos de ejercitarse en ambientes contaminados, a la vez que proporciona recomendaciones prácticas y basadas en la evidencia para mitigar estos riesgos. Las estrategias sugeridas incluyen priorizar los espacios de entrenamiento interiores equipados con filtros HEPA o MERV-13, ajustar el horario, la intensidad y la duración del entrenamiento según los índices de calidad del aire, ofrecer pautas específicas para poblaciones vulnerables (como niños, ancianos y personas con asma o enfermedades cardíacas) y adoptar medidas de protección, como el uso de mascarillas N95, la hidratación y el cuidado de la piel. Estas directrices tienen como objetivo guiar prácticas de ejercicio seguras durante períodos de calidad del aire comprometida.

Palabras clave: Incendios Forestales; Calidad del Aire; Ejercicio.

1. Introduction

Over the past two years, Brazil has faced an alarming increase in wildfires, resulting in an environmental crisis of significant proportions and serious public health challenges (Ye et al., 2021). In August 2024, the country recorded one of the worst wildfire scenarios in two decades, indicating an 80% increase in fire outbreaks compared to the previous year, totaling

over 135,898 outbreaks by the end of August (INPE, 2024). The wildfires affected the Amazon, Cerrado, and Pantanal biomes. Consequently, more than 167 Brazilian cities declared a state of emergency (Portal CNM, 2024). In addition to climatic and land-use factors, investigations point to a possible criminal origin for many fires, especially in São Paulo, where the number of fire outbreaks in August surpassed the total for the previous year (G1, 2024). The combination of extreme drought and unusual weather conditions, such as cold fronts diverting smoke to densely populated regions, exacerbated the crisis, leading to an alarming deterioration in air quality and endangering the health of the Brazilian population.

Wildfire smoke, rich in fine particulate matter (PM_{2.5}, PM₁₀), has direct and harmful impacts on human health. Both short- and long-term exposure to these pollutants increased systemic oxidative stress and body inflammation, elevating the risk of respiratory and cardiovascular diseases (Nassan et al., 2021). In Brazil, wildfire periods are estimated to result in around 47,000 annual hospitalizations. A comprehensive study analyzing over 143 million hospitalizations in 1,814 municipalities, covering 80% of the Brazilian population over 16 years, revealed that even brief exposure to PM from smoke can trigger asthma, strokes, heart attacks, reduced lung function, and premature deaths (Ye et al., 2021). Additionally, wildfire-related air pollution is associated with decreased life expectancy, cognitive decline (Bos et al., 2014), alter skin's biophysics and reduce visibility, raising the risk of accidents and making the environment hostile to outdoor activities (Liang et al., 2023).

The wildfires impacting Brazil reflect a global trend of increased frequency and severity driven by climate change. Similar events have occurred recently in Canada and Europe. In January 2025, wildfires in the metropolitan area of Los Angeles elevated PM_{2.5} levels to over 480 µg/m³, 14 times above the daily limit established by the the U.S. Environmental Protection Agency (EPA), resulting in school closures and cancellations of high-performance training sessions (Los Angeles Times, 2025).

The objective of this communication is to outline strategies to mitigate these adverse effects and offer practical recommendations for exercising safely when ambient air quality is compromised.

2. Methodology

This study is a qualitative bibliographic survey in the form of a narrative literature review, considered the simplest format with fewer formal requirements (Pereira et al., 2018). It is aimed at compiling findings on wildfires, air quality, and physical exercise, with a focus on the applicability of recommendations to the Brazilian context.

Searches were conducted non-systematically in the PubMed database, complemented by institutional documents and guidelines from national and international organizations such as the National Institute for Space Research (INPE)/Queimadas Program, the São Paulo State Environmental Agency (CETESB), and the World Health Organization (WHO).

We included observational studies, clinical trials, reviews, guidelines, and/or technical reports that addressed at least one of the following domains: (a) effects of air pollution: emphasizing wildfire smoke/particulate matter, on the practice of exercise and/or physically active populations; (b) strategies or recommendations to mitigate exposure during outdoor exercise. Studies that did not address any of these domains were excluded.

The recommendations presented derive from integrating findings from the literature with guidance issued by institutions that provide general information for populations exposed to poor ambient air quality.

3. Results and Discussion

3.1 Physical activity/exercise, environment and air pollutants

It is undeniable that regular exercise is crucial for health promotion and disease prevention. Owing to its substantial benefits, participation in exercise is routinely recommended (Klaperski et al., 2019). Where activity is performed can shape

both behaviour and outcomes, and outdoor sessions often amplify the gains observed indoors (Bramwell, Streetman, & Besenyi, 2023; Noseworthy et al., 2023). In comparison with indoor workout, exercising outside lowers blood pressure, heart rate, and cortisol levels, improves humor, reduces stress related emotions, and enhances working memory and concentration (Boere et al., 2023; Klaperski et al., 2019). However, air quality is a critical factor that directly influences the safety and effectiveness of these activities. Exercising outdoors becomes a challenge during episodes of air pollution, such as those caused by wildfire smoke.

During exercise ventilation rises, increasing the volume of inhaled air, and therefore pollutants (Cruz et al., 2021). Because individuals engaged in exercise tend to breathe through the mouth, bypassing the nasal cavity, which is responsible for filtering a large portion of harmful particles. Under normal physiological conditions, about 80-90% of these particles are captured by the nasal mucosa and eliminated through the gastrointestinal tract. Consequently, more pollutants to reach the lungs, water and CO₂ loss rises, which can affect physical performance and dry out the respiratory tract, reducing the action of cilia that help remove contaminants. Higher airflow velocities also reduce particle deposition into the upper tract, allowing pollutants to penetrate deeper and raise respiratory diseases risk (Daigle et al., 2003).

This issue would not be a concern if the air did not contain high levels of pollutants. However, in regions severely affected by wildfires, there is a significant increase in pollutants. In this scenario, public health authorities have recommended suspending outdoor activities, especially for more vulnerable groups, such as children, the elderly, and people with pre-existing respiratory conditions.

Nevertheless, for the general population, the question remains: is it worth engaging in physical exercise in polluted environments? In 52,061 adults aged 50 – 65 years, physical activity lowered mortality from diabetes and cardiovascular disease regardless of pollution exposure (Andersen et al., 2015). In a national cohort of 1,469,972 young adults aged 20 –39 years, cutting back physical activity under low to moderate levels of PM_{2.5} or PM₁₀ increased cardiovascular risk, whereas high levels to physical under high air pollution, nullified these benefits. According to the authors, it is recommended to maintain physical activity for those exposed to low or moderate levels of pollution, while increasing physical activity in environments with less pollution is necessary to prevent negative impacts on cardiovascular health in areas with high air pollution (Kim et al., 2021).

On the other hand, another longitudinal cohort with 4,537 participants, showed that each 10 µg/m³ increase in PM_{2.5} lowered physical function scores. However, an extra 10 Metabolic Equivalent (MET)-hour/week of physical activity improved them, suggesting that physical activity may reduce the impact of PM_{2.5} on human health (Jiang et al., 2023).

3.2 Recommendations and strategies to mitigate the effects of air pollutants during outdoor exercise

The absence of national guidelines that relate the Air Quality Index (AQI) to outdoor exercise exposes recreational runners and cyclists to potentially harmful concentrations of pollutants. Although the National Institute for Space Research issues daily bulletins on heat sources and air quality, these data reach the public without any adaptation protocols, unlike international references already addressing this challenge. The World Health Organization, for example, and the International Olympic Committee's 2025 consensus review on air quality, respiratory health and athletic performance both recommend individual measures to reduce pollution exposure and modulate physical effort, yet a universally adopted sports standard has still not emerged (Bougault et al., 2025; World Health Organization, 2020).

Closing this gap in Brazil calls for a multilevel response that includes AQI-based action bands, alerts integrated into training apps, and educational campaigns aimed at practitioners. The Table 1, below, summarizes practical counseling parameters, indicating adjustments in environment, intensity, risk profile, and support measures.

Table 1 - Practical Recommendations for Safe Exercise During Episodes of Poor Air Quality.

Domain	Why it matters	Operational actions
<i>Environment</i>	Air filtration and dispersion determine the final PM _{2.5} concentration that reaches the lungs.	<ul style="list-style-type: none"> Choose indoor spaces with HEPA or MERV-13 filtration whenever AQI > 150 (World Health Organization, 2020). If you must train outdoors, go out before 07:00 AM or after 20:00 PM, away from busy roads. Prefer tree-lined parks or seaside promenades, which disperse pollutants faster than urban “canyons” (Riondato et al., 2020).
<i>Session parameters</i>	Inhaled dose = concentration × ventilation × time.	<ul style="list-style-type: none"> Swap interval workouts for light-to-moderate continuous efforts when AQI > 100. Shorten total duration on high-AQI days. Save vigorous sessions for “green zone” days (AQI < 50) or perform them indoors (World Health Organization, 2020).
<i>Population & risk</i>	Susceptible groups develop bronchoconstriction and endothelial dysfunction at lower thresholds.	<ul style="list-style-type: none"> Children, older adults, and people with asthma, COPD, or heart disease: avoid outdoor exercise above AQI 100 and keep rescue medication close by. Healthy adults may tolerate brief exposures up to AQI 150 if all other precautions are followed.
<i>Support measures</i>	They mitigate irritative and oxidative effects but do not replace exposure control.	<ul style="list-style-type: none"> Wear a well-fitted N95/P100 respirator for efforts ≤ 60 % $\dot{V}O_{2max}$ when AQI > 150 (da Silva Lima et al., 2023). Stay well hydrated to minimize airway dryness. Use broad-spectrum sunscreen, wrap-around goggles, and post-workout moisturizer to limit skin and eye damage. Check AQI apps or sensors hourly to decide whether to postpone, shorten, or relocate the session.

HEPA: High-Efficiency Particulate Air. MERV-13: Minimum Efficiency Reporting Value – level 13. AQI: Air Quality Index. $\dot{V}O_{2max}$: maximal oxygen uptake. COPD: chronic obstructive pulmonary.
Source: Research Data (2024).

4. Conclusion

With the increasing popularity of street running and outdoor exercise in Brazil and other countries, it is essential for practitioners and health professionals (especially that not related to exercise and sports science) to be aware of the importance of checking air quality conditions before exercising. While outdoor physical activity offers numerous benefits for physical and mental health, these can be compromised when performed in polluted environments. Therefore, the balance between the benefits of exercise and safety regarding pollution exposure must be carefully considered. Adapting exercise practices, constantly monitoring air quality, and adopting mitigation strategies are fundamental steps to ensure that pursuing an active and healthy life does not turn into a health risk.

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