Air pollution – the unseen risk to a player's health and performance

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The rise in air pollution is currently attributed to 2 million premature deaths each year, ranking it the 13th leading cause of death worldwide.[1] Children and elite athletes are particularly susceptible to the negative effects of air pollution and so it is vital to educate them on the importance of preventative approaches to minimize associated risk factors, so as to maximize performance on court and live healthier lives. This article will briefly discuss 1) the composition of air pollution and how various components affect health and performance, 2) why children and elite athletes are particularly vulnerable to such effects, and 3) preventative strategies to deal with highly polluted areas.

Introduction to air pollution

Air pollution comes in the form of particles or gases, and is produced directly from a source or indirectly formed in the atmosphere. The level of air pollution can vary dramatically from country to country (figure 1). The World health Organization (WHO) air quality guidelines for acceptable exposure to particular pollutants are listed in Table 1.

Figure 1: Average air pollution of particulate matter with an aerodynamic diameter of 10 μm or less (PM10) in urban areas

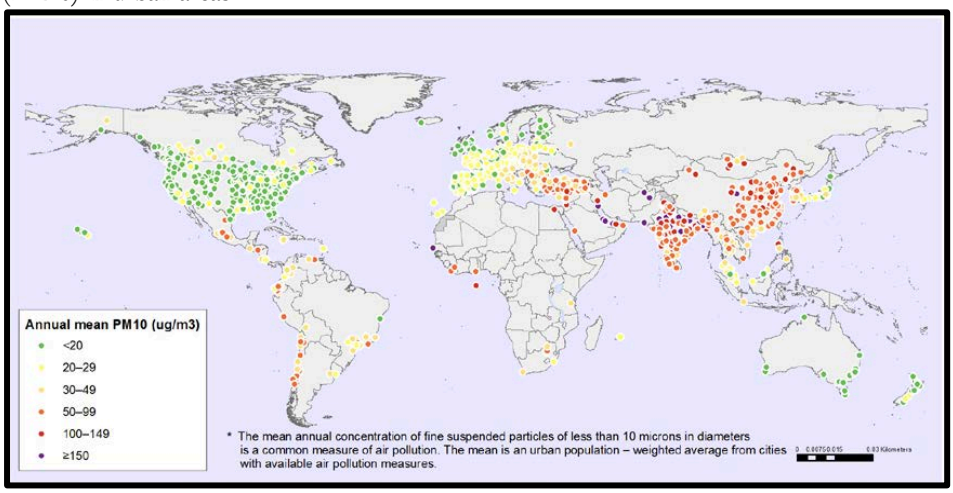


Table 1: World Health Organization air quality guidelines for acceptable air pollution exposure.

Pollutant	Average period		
	Annual	24 hours	8 hours
$PM_{2.5}$	10 μg/m^3	25μg/m^3	
PM_{10}	20 μg/m^3	50μg/m^3	
Ozone			50ppb
Carbon monoxide			9ppb

PM = particulate matter, *ppb* = parts per billion, ppm parts per million, PM_{10} = PM with a mean aerodynamic diameter of 10 μm or less, $PM_{2.5}$ = PM with a mean aerodynamic diameter of 2.5 μm or less

Particulate Matter (PM)

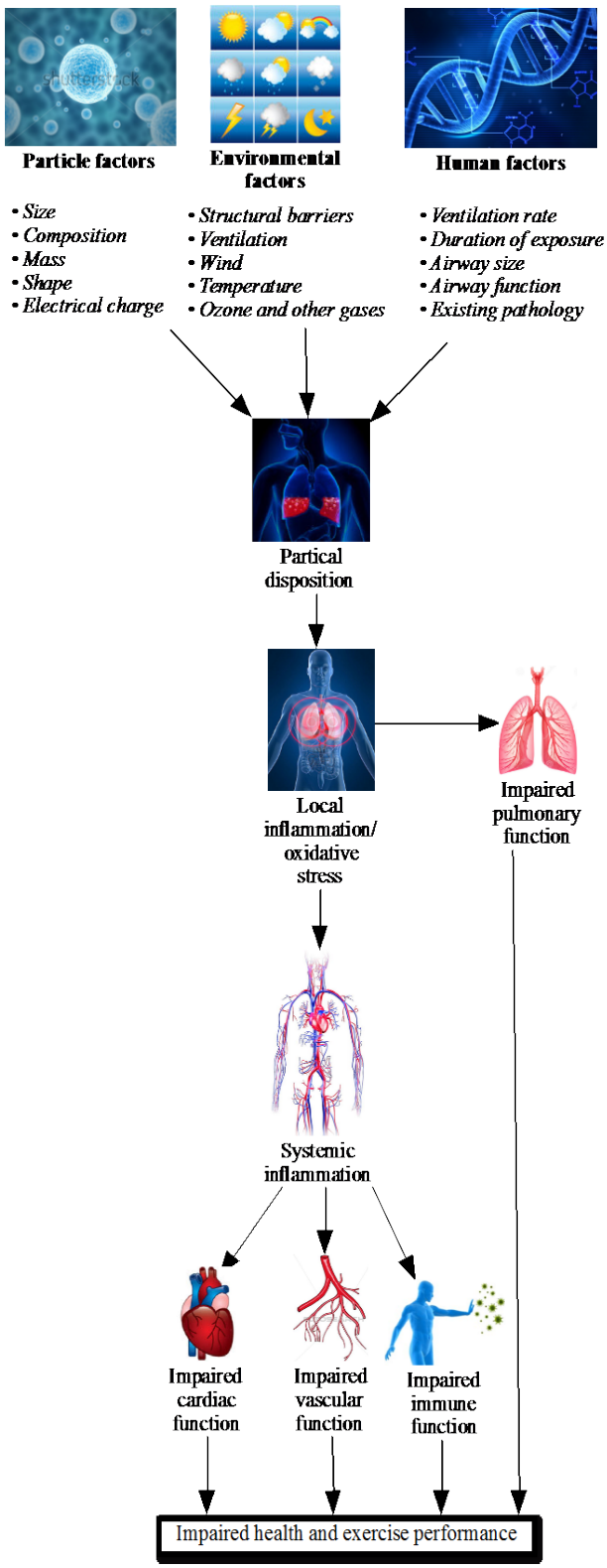
Particulate matter is a mixture of liquids and solids that vary in size and chemical composition. Sources of particulate matter include burning of fuel, gases released from power plants, motor vehicle exhausts, and natural sources such as wind-blown dust and wildfires. Exposure to particulate matter is linked with many heart and lung disorders (such as asthma, atherosclerosis, stroke, bronchitis, and myocardial infarctions) and even diminishes the beneficial effects of exercise on cognition.[2] Beijing $PM_{2.5}$ concentrations can surpass 250 $\mu g/m^3$ within a 24-hour period [3], an amount 10 times greater than the WHO guidelines.

Carbon Monoxide

Carbon monoxide is gas emitted from burning fuels containing carbon (e.g. car exhausts fumes and power plants). Carbon monoxide has over 200 times greater affinity for hemoglobin than oxygen does which reduces the oxygen carrying capacity in the blood, subsequently leading to an inadequate oxygen delivery to muscles and organs (tissue hypoxia) and impairing exercise performance.[2] Exposure to carbon monoxide may induce oxidative stress and impair mitochondrial function, ultimately affecting energy production.[2] European cities contain nearly double that of the WHO 8 hour guidelines (17 ppm) in a typical 8-hour period, with peaks around 53 parts per million.

Ozone

Ozone is formed when precursor pollutants (such as nitrogen dioxide and organic compounds) interact with sunlight (for example, burning fire crackers). Ozone is a respiratory irritant that causes lung inflammation, heart rate variability and may interfere with lung defense mechanisms, ultimately increasing a players' risk of infections (i.e. upper respiratory tract infections).[2] The United States often exceeds the WHO 8 hour ozone upper limit.[4]



The vulnerable child & athlete

Children

Children are particularly predisposed to the detrimental effects of air pollution for several reasons:

1. Their lungs are still growing. The number of alveoli expands from 24 million at birth to 267 million at 4 years old, and by adulthood it reaches 600 million![5] Lung development

relies on an integral sequence of complex and precisely timed chemical signals to occur which are interfered with by many air pollutants.[6]

2. Compared with adults, children breathe in twice as much air per body weight during rest and they spend more time outdoors and engaged in physical activity (particularly in the summer and late afternoon when air pollution levels are highest).[7] Once exercising, they are subjected to 5 times greater deposition of particles entering into the lungs than at rest.[8]
3. Children have poor defense mechanisms against air pollutants because firstly, the lining of their airways are more permeable to toxic particles and gasses allowing them to enter the circulation, and secondly children are less effective at getting rid of them.[9]

Elite athletes

The prevalence of airway dysfunction is much higher in athletes than non-athletes, affecting 25-75% of competitors.[10, 11] At both the summer and winter Olympics, exercise-induced asthma is the most common chronic medical condition experienced[12] and symptoms suggestive of upper respiratory tract infections make up 30-40% of all visits to sports medicine clinics by elite athletes.[13] For tennis players competing at the US Open, ear, nose, and throat complaints have shown a linear increase since 1994 and are responsible for a third of all acute medical illnesses.[14] Another third of acute illness are due to allergies, respiratory illnesses and environmental factors[14] all of which can be affected by air pollution.

Respiratory experts are now considering whether airway dysfunction in elite athletes should be classified as an occupational lung disease, and there is good reason why.[15] Elite athletes more exposed to air pollution because they train up to 3 times a day at ventilation rates 20-30 times higher than at rest.[16] The higher ventilation rates change breathing patterns from nasal to predominately oral airflow causing a larger amount of dry air to reach the lungs with airborne allergens and other inhaled particles (e.g. pollutants).[16]

During exercise, the increased depth in breathing to meet the oxygen cost of working muscles causes a transient disruption in the airway lining that leads to airway injury and inflammation in both healthy and asthmatic athletes.[17] Professional tennis players are subjected to frequent international travel and experience inadequate recovery, making them more susceptible to contracting infections, for example, respiratory tract infections triggered by air pollution.

10 Preventative strategies

When feasible:

1. Ensure a diet rich in vitamin C and E (such as fruits, vegetables and fish oil) or consider antioxidant supplementation especially when traveling or training in highly polluted areas. Antioxidants have been shown to protect against the harmful effects of air pollution on lung function and injury.[18-20]

Before training

2. Consider the environment prior to and during exercise, and how travel to training sites could alter exposure.
3. Follow local air quality forecasts and train to avoid peak pollution levels. Click here to find out what countries are highly polluted and here to analyze daily air quality forecasts.
4. If traveling to highly polluted cities, plan to arrive as late as possible to minimize exposure. Alternatively, arrive around 4 days prior to competition to allow for the acute inflammatory changes to resolve before play.
5. Schedule training sessions in the morning throughout summer to minimize afternoon ozone exposure.
6. Pre-treatment with anti-asthmatics may protect against the harmful effects of air pollution during exercise. Athletes with preexisting respiratory conditions should consult their physician. Some anti-asthmatic drugs are prohibited by the World Anti-Doping Agency and therefore athletes should inform their physician if they are subjected to drug testing. It is the player's responsibility to keep up to date with the World Anti-Doping Agency's rules and regulations. Download current the 2015 prohibited list here.

During Training

7. Select training areas away from traffic as much as possible.
8. Ensuring a proper warm up of intermittent exercises will increase bronchial blood flow and the rate of water return to the airway surface, protecting athletes against airway epithelial injury and the likelihood of an asthmatic event in those prone to exercise-induced asthma.
9. Practice nose breathing during low-intensity training so that the air reaching the lungs humidified and therefore reduce the likelihood of airway injury.[21, 22]
10. A quality and properly fitted facemask is an effective preventative strategy to prevent airway injury[23, 24] yet it may be impractical to use at higher intensity exercises. If tolerated during low-moderate intensity exercises, it may be worth considering particularly in highly polluted areas. If your interested in buying a mask, select one that is labeled N95, which is a category of respirator certification given by the National Institute for Occupational Safety and Health indicating that the mask is certified to filter greater than or equal to 95% of all harmful particles greater than 0.3 microns in size. 3M, Vogmask and Totobobo are good brands to choose from.

As all athletes know, small things make a big difference, and this holds especially true about air pollution. We work with vulnerable athletes who are more likely to be exposed to the toxic effects of particles and gasses, and as air pollution becomes increasingly more prevalent worldwide, we need to be educating our players on such environmental issues so as to live healthier and perform better.

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