

Physical activity and sport competitions under air pollution conditions

Exposure to ambient air pollution may cause adverse health effects. It can lead to the development and/or exacerbations of pulmonary diseases such as COPD and asthma. Moreover, it is an important factor in the pathogenesis of cardiovascular diseases and even diabetes, and may increase mortality risk. Airborne particulate matter was defined as a potential carcinogen by the World Health Organization (WHO). Particulate matters (PM) are complex mixtures of extremely small particles and liquid droplets, made of acids, chemicals, metals, soil or dust particles. It is common to refer to PM as different fractions defined by size of the particles, measured in microns per meter cub or cm^3 , for example: PM_1 are particles that are one micron in diameter or smaller, and PM_{10} are particles with the diameter of up to 10 microns. The size of the particles is directly linked to their potential for causing health problems, as the smaller the particle is, the deeper the particle can get into the lungs and the bloodstream.

Children have been defined as a sensitive group to air pollution influence: their body systems (heart, lung and brain) are still developing, they spend more time outdoors (Natural Resources Defense Council website), they breathe more air than adults (air volume to body weight) and therefore have greater exposure when the air is polluted. Additionally, because of young children's height and play habits (crawling, rolling) they are more likely to be exposed to pollutants that are heavier than air and tend to concentrate in their breathing zone near ground level. Furthermore, children are usually more active than adults, especially when they are outdoors (playing, running etc.).

During physical activity, breath ventilation (ventilation volume per minute) and the volume of air entering the body significantly increases, for example athletes can breathe

more than 150 liters of air per minute (compared to 5-6 liters per minute at rest). Moreover, during aerobic exercise, there is a shift from nasal breathing (in which an initial pollutants filtering is carried out) to mouth breathing, resulting in large amounts of unfiltered air that enters the body, and pollutants that are carried deeper to the lungs. Therefore, physical exercise under ambient air pollution can lead to higher exposure to pollutants, relative to the exposure of a non-active person under the same environmental conditions. Exposure to air pollutants is proportional to the physical activity duration, for example, long-distance running or football under conditions of air pollution will expose the athlete to more air pollution than running 100 meters under similar conditions.

It was shown that exposure to high levels of specific air pollutants such as Ozone (O₃), Carbon monoxide (CO), Nitrogen dioxide (NO₂), Sulfur dioxide (SO₂), and particle matters (PM₁, PM₁₀, PM_{2.5}), during physical activity may have health effects: It can cause cough, pains in the chest, difficulties in breathing, sore throat, and headaches and decrease lung function. Exposure to O₃, for example, may produce free radicals causing oxidative stress which may damage epithelial cells, induce inflammatory processes and cause direct damage to the lungs (Florida-James et al. 2004). Studies have shown that exercising under conditions of high O₃ levels can be associated with the development of asthma, and with cytogenetic damage in lymphocytes.

Aerobic training under conditions of air pollution (higher levels of CO, Ozone, and PM₁₀), was shown to lead to decreased levels of red blood cell counts, and increased levels of white blood cell.

Although athletes' vascular and pulmonary systems are more developed and trained relative to the general population, their exposure to air pollution conditions while

exercising may also have health effects, decrease their lung functions and their performances. Repeated exposure of athletes to high levels of air pollution was shown to induce inflammatory processes and was associated with developing asthma or airway hyperresponsiveness, to pulmonary inflammation and to vascular endothelial dysfunction.

Of note, several studies have shown that physical activity under air pollution conditions do not cause immediate clinical problems, but rather reduces the health benefits of the exercise, and that moderate exercise, even when carried out under air pollution conditions, increases the lung function.

Due to the potential adverse health effects of physical activities under conditions of air pollution, health organizations around the world published recommendations and guidance for the general public and for vulnerable populations (*e.g.*: the elderly or sick people) in reducing the health impacts of air pollution regarding general and physical activities. Most of these organizations recommend not to perform vigorous physical activity under severe air pollution.

However, most of these recommendations are general and do not refer to sports competitions, and there are no formal procedures for coping with sports competitions under air pollution condition. There are several examples for specific *Ad Hoc* action for coping with these challenges. For Example, in September 2015, the Israeli football association canceled several football games due to sandstorms, and in December 2015 Iran's premier football league postponed two games over the weekend due to high concentrations of air pollution. Another example relates to the Olympic games. The International Olympic committee (IOC) does not have a formal air quality policy regarding canceling Olympic competitions due to air pollution. However, in preparation

for the Beijing 2008 Olympic games, the IOC Medical Commission established an Air Quality Expert Panel (AQEP) to monitor air quality prior to and during the Olympic games, and advise the IOC. The AQEP defined several Olympic competitions that are at greater risk to air pollution due to their duration (more than an hour) and intensity, such as marathons, triathlons and cycling road races. The panel defined an unacceptable air pollution threshold as $150 \mu\text{g}/\text{m}^3$ (24 hours concentration) of PM_{10} , according to the Interim Target-1 of the World Health Organization (WHO) air quality guidelines for 2005. Eventually, the significant efforts done by the Chinese government to reduce air pollution were effective and the air pollution was reduced. However, there is currently no recognized regulation, procedure or standard regarding canceling or postponing of professional sport competitions due to sandstorms or high level of air pollution.

When examining thresholds for cancelling sports competitions, we focus on the athletes' health. Athletes have higher ventilation rates and therefore may potentially be exposed to more ambient contaminants. However, professional athletes may have higher tolerance for ambient contaminants, and therefore can be considered as workers (and their exposure to the risk can be considered as an occupational exposure). Workers in general, and particularly athletes, are considered healthier than the general population, since they do not include individuals who are very old, sick or very young. In addition, they are not exposed to the pollutant for an entire lifetime. This is known as the "healthy worker effect", a well established term in occupational epidemiology. Consequently, it is common to use one order of magnitude (multiple by 10) in order to convert environmental values (related to the public) to occupational values (values related to workers that are exposed on a daily basis).

Israel is affected by dust storms which mostly increase the level of PM₁₀. This poses a significant threat on human health. Therefore, it was decided to relate to PM₁₀ threshold values for cancelling sports competitions. The alert value (the level beyond which there is a real risk to human health, even for short-term exposure and as of which immediate steps must be taken) for PM₁₀, according to the Israeli Ministry of environmental protection, is 300 µg/m³ per 24 hours and the ambient value (the level beyond which there is a potential risk to human health) is 130 µg/m³ per 24 hours. Of note, the typical PM₁₀ levels in Israel are lower than 50 µg/m³ per 24 hours, but levels of above 1,100 µg/m³ per 24 hours were also measured in several regions in Israel. The alert value is the base for determining the PM₁₀ threshold values, in which outdoor physical activities and/or sport competitions should be canceled, depending on the age of the players/athletes:

(a) Professionally trained adults – As previously discussed, trained adult players can be referred as workers, since training is their occupation. Therefore, the threshold value for canceling adults outdoor sport activities (for trained individuals) should be the ambient value multiplied by the occupational factor (10), and is therefore 1300 µg/m³ per 24 hours of PM₁₀.

(b) Trained youth, ages 16-18 - the value for canceling older youth outside sport activities is the same as the adults: 1300 µg/m³ per 24 hours of PM₁₀.

(c) Younger youth, ages 14-16 - the threshold should be half of the adults' threshold, which is 650 µg/m³ per 24 hours of PM₁₀.

(d) Children (ages below 14) – since children are defined as a more sensitive group to air pollution, the alert value by law ($300 \mu\text{g}/\text{m}^3$ per 24 hours of PM_{10}) should be the threshold value.

Conclusions:

Most of the studies show that physical activity under outdoor air pollution conditions (moderate and high) may cause health damage for the public and specifically for athletes. The damage is dependent on the age, physical and health condition of the individual, the activity endurance and type, and mostly on the type and level of air pollution. Therefore, and according to the "Precautionary principle", it is recommended both for the public and for players/athletes, to completely avoid any physical activity under severe air pollution conditions, including activity of daily living. In addition, it is recommended to cancel any outdoor physical activity or sport competition in case of severe air pollution, according to the aforementioned recommendations.

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