UNDERSTANDING AIR QUALITY: A GUIDING DOCUMENT FOR SPORT ORGANIZATIONS

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INTRODUCTION AND OVERVIEW

Environmental factors such as precipitation, extreme temperatures, lightning, and air pollution can adversely impact the health and performance of sport participants during outdoor training and competition. To protect all sport participants, including coaches, officials, and spectators from exposure to environmental factors, sport leaders must be able to make informed decisions about when to modify, cancel or reschedule outdoor events. While there is a broad understanding of how to protect participants from lightning, few understand how to protect sport participants from poor air quality.

Poor air quality can have short- and long-term effects on human health, ranging from eye, nose, skin and throat irritation to asthma and lung cancer (HC, 2021). Outdoor sport participants are at a higher risk of health problems when exposed to air pollution than the general population. This is due to the increased oxygen demand associated with physical activity (Carlisle & Sharp, 2001; Giles & Koehle, 2014). To meet this oxygen demand, we breathe more deeply and rapidly (Carlisle & Sharp, 2001; Giles & Koehle, 2014; EPA, 2011). Additionally, the harder we exercise, the more we breathe through our mouths rather than our noses (Carlisle & Sharp, 2001; Giles & Koehle, 2014). When we increase the volume of air that we breathe and bypass the body's built-in filtration system in the nose, we not only inhale more air pollutants but also inhale them more deeply into our lungs (Bateson & Schwartz, 2007). This increases the risk of adverse health from poor air quality.

Sport organizations are responsible for protecting those participating in outdoor sports and physical activities. This includes preventing and limiting participants' exposure to air pollution in outdoor settings. This guiding document was created to provide sport organizations with key research and evidence to support the development of air quality policies which aim to prevent and limit all outdoor sport participants' exposure to air pollution.

Using credible research and evidence, this guiding document will:

- Define air pollution, sources of air pollution, and key air pollutants (Section 1)
- Identify events (wildfires, temperature inversions, and smog) that contribute to poor air quality in Canada (Section 2)
- Describe the adverse health effects of exposure to air pollutants (Section 3)
- Explain why sport participants are at increased health risk (Section 4)
- Describe the Air Quality Health Index (AQHI) and its role in planning and managing sport events and activities to prevent or limit participants' exposure to air pollution (Section 5)
- Provide additional resources (for example, policy suggestions) for continued learning on the topic of air pollution and outdoor sport safety (Section 6)

COMPLEMENTARY RESOURCES

Health Canada engaged the Sport Information Resource Centre in 2022 to help support its air quality and outdoor sport safety initiatives. The project had two phases. The first phase involved the development of an online learning module and outreach materials. These educational resources were designed to help coaches and sport officials recognize the impact of poor air quality, and use the Air Quality Health Index (AQHI). The second phase involved the creation of this guiding document and complementary policy template designed to provide sport organizations with the information and tools to take proactive measures to prevent and limit all outdoor sport participants' exposure to air pollution. To access the online learning module, outreach materials, and policy template, visit http://sirc.ca/air-quality-and-sport.

To explore the resources created through this partnership, visit www.sirc.ca or reach out to the SIRC team at info@sirc.ca. Additional resources are listed at the end of this document.

SECTION 1:
AIR POLLUTION

Air pollution is a mixture of chemical, physical and biological agents that contaminate indoor and outdoor environments (WHO, 2022b). In Canada, the highest emissions of air pollutants have been linked to electricity generation, construction, oil and gas industries, forest fires, transportation, agriculture and wood burning (GoC, 2022b). Some of the most harmful air pollutants to human health include particulate matter (PM), ground-level ozone (O3), nitrogen dioxide (NO2), volatile organic compounds (VOCs) and sulphur dioxide (SO2; GoC, 2022b). Below is a summary of each of these key pollutants.

1.1 Particulate Matter

Particulate Matter (PM) consists of airborne particles, such as dust, and liquid droplets (Anderson et al., 2012). PM can be made through human activities like vehicle emissions or through natural sources like forest fires (Anderson et al., 2012). PM is categorized based on size, with the smallest particles having the most significant impact on human health as they can travel deep into the lungs, where they are later absorbed into the bloodstream (GoC, 2021a). The smallest and most harmful type of PM is called fine particulate matter or PM2.5 (Anderson et al., 2012; GoC, 2021a). PM2.5 can have many short and long-term health effects (Anderson et al., 2012). For example, short-term exposure to PM2.5 has been associated with reduced lung function, respiratory infections and asthma aggravation (Anderson et al., 2012; Kurt et al., 2016). In the long term, PM2.5 has been associated with an increased risk for diseases like stroke, heart disease and cancer (Anderson et al., 2012; Kurt et al., 2016).

1.2 Ground-level Ozone

Ground-level ozone (O3) is colourless and highly irritating gas (GoC, 2022c). It is a secondary pollutant formed when NOx and VOCs interact in the presence of sunlight (GoC, 2022c; Sicard et al., 2021). O3 can significantly impact human health (GoC, 2022c; Sicard, 2021). For example, it has been linked with the aggravation of respiratory illnesses, increased hospital visits and pre-mature mortality (GoC, 2022c). O3 and PM are major precursors to smog formation.

1.3 Volatile Organic Compounds

VOCs can enter the body through various routes, including inhalation, ingestion and from skin absorption (Xiong et al., 2020). VOCs have many health effects, including causing irritation to the eyes, nose and throat as well as leading to an increased risk of diseases like cancer (GoC, 2017; Kampa & Castanas, 2008; Rumchev et al., 2007).

1.4 Nitrogen Dioxide

Nitrogen oxide is emitted from combustion sources and rapidly reacts with oxygen or ozone to form nitrogen dioxide (NO2; GoC, 2021a; Kampa & Castanas, 2008). NO2 interacts with other gases and particles in the air to form PM and O3, both of which have harmful effects on human health (GoC, 2021a). NO2 can affect respiratory health, causing airway inflammation, reduced lung function and asthma aggravation (GoC, 2021a).

1.5 Sulphur Dioxide

Sulphur dioxide (SO2) is a strong-smelling colourless gas emitted when sulphur-containing materials are burnt (GoC, 2013; Kampa & Castanas, 2008). As such, SO2 levels are often highest near industrial plants (GoC, 2013). SO2 has been linked to adverse respiratory health (GoC, 2013). In the short term, SO2 can lead to symptoms like chest tightness, while in the long term, it can lead to reduced lung function (GoC, 2013).

SECTION 2:
ENVIRONMENTAL EVENTS THAT CONTRIBUTE TO POOR AIR QUALITY

In Canada, environmental events can contribute to poor air quality. A description of three types of events that contribute to poor air quality and increased health risk (wildfires, temperature inversions, and smog) are described below.

1.1 Wildfires

Wildfires typically occur between April and October and can negatively impact air quality because their smoke contains carbon monoxide, NO2, VOCs, and PM (Black et al., 2017). It is important to recognize that the smoke from wildfires can disperse over great distances, so even if sport participants are kilometers away from a wildfire, they may be affected by the wildfire smoke (Black et al., 2017). Wildfire smoke can impact everyone (GoC, 2021b). The health effects from wildfire smoke can range from mild to severe symptoms (Black et al., 2017; GoC, 2021b). Some mild symptoms include a cough or the exasperation of asthma symptoms, while more severe symptoms include chest pains and wheezing (GoC, 2021b). In the event of a wildfire, outdoor physical activity should be limited. Best practices include rescheduling activities to a later date or, where possible, moving activities indoors (GoC, 2021b).

1.2 Temperature inversions

Temperature inversions can also contribute to poor air quality across Canada. Temperature inversions are most common in areas with low elevation, like valleys (GoC, 2014). A temperature inversion occurs when a layer of cold air gets trapped below warm air (EEA, 2020). Here the warm air acts as a lid, keeping the cold air and pollutants close to the ground (EEA, 2020). This results in high concentrations of air pollutants.

1.3 Smog

Smog is a mixture of air pollutants that often appears as haze in the air, reducing visibility. It is comprised of a mixture of gases and particles (GoC, 2014). While many pollutants contribute to smog, the two primary pollutants in smog are PM and O3 (GoC, 2014). High smog levels are often associated with warmer summer months, but smog can occur year-round (GoC, 2014). For example, in the winter, smog levels can increase as pollutants build up at ground level as a result of being trapped under a layer of warm air (temperature inversion; GoC, 2014). Increased wood burning and vehicle emissions can also contribute to increased smog levels in winter (GoC, 2014). Exposure to smog has been associated with increased hospital and doctor visits as well as premature deaths (GoC, 2014).

SECTION 3:

ADVERSE IMPACTS OF AIR POLLUTION ON HEALTH AND ATHLETIC PERFORMANCE

Air pollutants can lead to short- and long-term health effects. Some of the more common and mild short-term health effects include irritation of the skin and eyes, mild coughing, headaches, and respiratory irritation (HC, 2021). More severe short-term symptoms can include difficulty breathing, chest tightness, wheezing, and worsening of pre-existing medical conditions (HC, 2021). In the long term, exposure to air pollution can result in cardiovascular and respiratory disease, such as an increased risk of developing lung cancer, asthma, and even premature death, especially for individuals with pre-existing chronic medical conditions such as lung and heart diseases (HC, 2021). In Canada, it is estimated that air pollution contributes to 2.7 million asthma symptom days and 15,300 premature deaths (HC, 2021). It is important to note that while the long-term health effects of air pollution can take years to develop, the short-term health effects can occur within minutes of exercising in an environment where the air quality is very poor. In addition, exposure to wildfire smoke reduces an athlete's lung function, which means there is less oxygen intake, and affects their performance.

While all outdoor sport and physical activity participants are at risk of experiencing the adverse health and performance impacts of poor air quality, some participants may be at an increased risk (Sandford et al., 2020). As such, additional consideration may be needed for some participants, such as those with pre-existing medical conditions, to ensure their safety when engaging in outdoor sports.

SECTION 4:
WHY SPORT PARTICIPANTS ARE AT INCREASED RISK

When a person engages in physical activity outdoors, they require more oxygen (Carlisle & Sharp, 2001; Giles & Koehle, 2014). The greater the intensity of the activity (the "harder" they exercise), the more oxygen their body requires. To meet the body's increased oxygen demands, the individual breathes more deeply and more frequently (Carlisle & Sharp, 2001; Giles & Koehle, 2014; EPA, 2011). This can be seen in Figure 1, which shows that the breathing rate of the average adult and 10-year-old child increases as they go from rest to heavy-intensity exercise (EPA, 2011). Interestingly, children may be more susceptible to the effects of air pollution, as they breathe in greater volumes of air relative to their body size when compared to adults (EPA, 2011). Therefore, children and youth participating in outdoor sports activities can be at a greater risk than adult participants.

If the air quality is poor, increased air intake during exercise will also increase the volume of air pollutants that a person inhales. Additionally, a person will shift from breathing through their noses to breathing primarily through their mouths (Carlisle & Sharp, 2001; Giles & Koehle, 2014). Nasal breathing filters the air as it passes into the lungs, whereas mouth breathing bypasses the nasal filtration system (Bateson & Schwartz, 2007). This draws more air pollutants deeper into the lungs, where they diffuse into the bloodstream more rapidly.

Athletes who exercise in areas with high air pollution (for example, urban settings) inhale greater amounts of air and, therefore, a greater amount of air pollutants than those who are not physically active in the same environment. For example, research indicates that there is a 6-to-10-fold increase in the total number of particles that are deposited into an individual's airway during high intensity exercise when compared to at rest (Giles & Koehle, 2014).

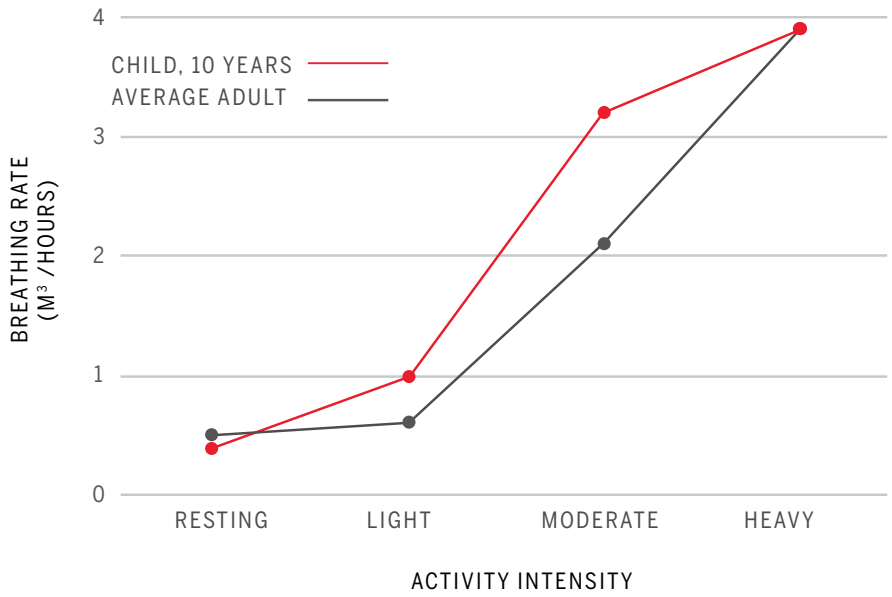

Figure 1. A graph showing the breathing rates for adults and children at varying levels of physical activity. This figure was adapted from tables 6-28 in the United States Environmental Protection Agency's Exposure Factors Handbook (2011).

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SECTION 5:
THE AIR QUALITY HEALTH INDEX (AQHI)

The Air Quality Health Index (AQHI) resources on the Government of Canada's website informed the information presented in this section. To learn more, visit AirHealth.ca or download the WeatherCAN app.

The AQHI was created to help individuals understand and make decisions about the safety of the air around them. Sport participants can use the AQHI to help monitor their local air quality and make informed decisions about the safety of outdoor sport participation. The AQHI presents the relative health risk associated with the combined health effects of air pollutants, including NO2, PM2.5 and O3. The AQHI is presented on a scale of 1 to 10+, which are further grouped into four health risk categories ranging from low risk (1 to 3), moderate risk (4-6), high risk (7-10) and very high risk (10+; Figure 2).

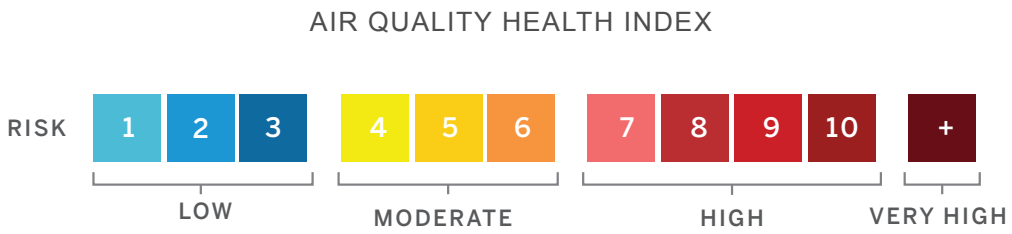

Figure 2. The AQHI scale and associated health risk categories.
Image retrieved from AirHealth.ca.

The AQHI is presented as observed and forecasted values. The AQHI values are accompanied by health messages. These messages can be used to support decisions around the safety of outdoor sport participation. Below are some general guidelines on how the AQHI can be used for outdoor activity planning. It is also up to coaches, sport officials and organizations to assess the needs of their participants as well as their environmental conditions to determine if outdoor sport participation is safe.

- When the health risk is **low (AQHI 1 to 3)**, it is the optimum time to schedule and participate in outdoor sport and physical activities.
- When the health risk is **moderate (AQHI 4 to 6)**, outdoor activities may still be held. However, particular attention should be given to participants with pre-existing medical conditions such as asthma.
- When the health risk is **high (AQHI 7 or above)**, outdoor events should be cancelled, re-scheduled, or moved to an indoor location whenever possible.

SECTION 6:
RESOURCES FOR CONTINUED LEARNING

This guiding document is intended to provide outdoor sport organizations with key research and evidence to support policy development and other proactive measures to prevent and limit outdoor sport participants' exposure to air pollution. When air quality is poor, it is important to modify outdoor activities to protect the health of outdoor sport and physical activity participants, as poor air quality can impact health.

An important next step for sport organizations is to develop air quality policies that support safe outdoor sport participation. The policies should provide guidance on appropriate actions to take during poor air quality events, and establish education and training expectations on AQHI for coaches and sport officials.

Below are some suggested training and resources to help you learn more about air pollution and what your organization can do to help keep outdoor sport participants safe from the effects of air pollution.

For more information or support with creating your organization's Air Policy please contact the SIRC team at info@sirc.ca.

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- Air Quality and Outdoor Sport Safety eLearning Module
- About the Air Quality Health Index (AQHI)
- Canada's Air Quality
- Outdoor Air pollution and health: An overview
- The Health Impacts of Air Pollution in Canada
- Sport at Risk: Addressing Climate Change in the Canadian Sport Sector
- Sport for Climate Action
- Reducing the Carbon Footprint of Spectator and Team Travel
- Let's Talk About Air Pollution: Keeping Outdoor Sport Participants Safe

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