

Opinion

PM<sub>2.5</sub>: A barrier to fitness and health promotion in China

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1. Introduction

Physical inactivity has been identified as the fourth leading risk factor for global mortality.<sup>1</sup> Globally, it accounts for about 6% of deaths, 21%–25% of breast and colon cancers, 27% of diabetes, and 30% of ischemic heart disease.<sup>1</sup> In China, the economic costs of health diseases due to physical inactivity had reached 6.7 billion US dollars in 2007, which accounted for more than 15% of the yearly medical and non-medical costs caused by the main non-communicable diseases.<sup>2</sup> Physical activity (PA) has thus been recommended and promoted by renowned organizations, such as World Health Organization (WHO), Centers for Disease Control and Prevention, and American College of Sports Medicine, due to its abundant health benefits.<sup>1,3,4</sup> However, PA and national fitness promotion have been challenged and threatened by severe air pollution in China during its fast and massive industrialization and urbanization.<sup>5,6</sup> Among air pollutants, PM<sub>2.5</sub> (particulate matter (PM) with a mean aerodynamic diameter of 2.5 μm or less), because of its debilitating effects on health,<sup>7,8</sup> has caused extensive public concern, received numerous negative media reports, and therefore presents another public health challenge in populous China.

2. PA, fitness, and health promotion in China

Since 1995, a national fitness program has been carried out by the central government of China to promote PA and improve fitness in the general population.<sup>9</sup> In 2014, this fitness program was listed as a national strategy. In 2016, a new Healthy China 2030 Blueprint was released to improve overall population health over the next 15 years.<sup>10–12</sup> Based on the health achievements so far, the blueprint indicated that new health challenges have emerged due to changes in industrialization, urbanization, mean age of population, environment, and life style, and these

need to be addressed by national strategies. As a result, healthy lifestyle promotion was underpinned and good habits such as regular PA were emphasized in this document. According to the blueprint, the Chinese central government ambitiously plans to increase the number of people participating in exercise frequently (defined as people practicing moderate or vigorous exercise for 3 times or more per week lasting at least 30 min) from 360 million in 2014 to 530 million by 2030.<sup>12</sup> It further mentioned that children and adolescent students should enjoy at least 1 h of daily PA in schools and participate in moderate or vigorous exercise 3 times or more per week by 2030. Moreover, 4 specific strategies were introduced to improve fitness of the general population in this blueprint as follows: (1) improving national public fitness service system, (2) implementing national fitness campaigns extensively, (3) strengthening non-medical health interventions and the integration of PA and medical treatment, and (4) facilitating PAs in key populations of children and adolescents, women, elders, occupational groups, and the disabled.<sup>12</sup>

It is noteworthy that health benefits and importance of PA have been gradually recognized by Chinese people through 20 years of national fitness promotion. According to the latest national PA survey by the General Administration of Sport of China, 94.6% of Chinese school adolescents (6–19 years old) were involved in exercise at least once a week and about 410 million Chinese adults (over 20 years old) participated in exercise in 2014.<sup>13</sup> Compared to 2007, the number of Chinese adults participating in exercise had increased by 70 million in 2014, from 28.2% in 2007 to 33.9% in 2014. The survey further indicated that the most popular PAs in the Chinese people are outdoor activities such as walking, jogging, and ball sports.

3. PM<sub>2.5</sub> air pollution in China

Unfortunately, the general population (including those who exercise outdoors) has been often threatened by severe health-damaging air pollution in China, especially in relation to PM<sub>2.5</sub>. PM is the debilitating air pollutant that affects more people than any other pollutant, especially PM<sub>2.5</sub>, because of its deeper

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penetration within the lungs.<sup>7,8,14</sup> Convincing evidence has shown that PM exposure is associated with respiratory and cardiovascular diseases such as myocardial infarction, stroke, atherosclerosis, bronchitis, and asthma.<sup>7,15</sup> Three pathways are proposed to be involved in these diseases as follows: (1) pulmonary oxidative stress and inflammation, (2) perturbation of the autonomic nervous system, and (3) translocation of PM or its constituents in circulation.<sup>7</sup> Collectively, these pathways could contribute to increased systemic inflammation and oxidative stress, blood coagulation, vascular and endothelial dysfunction, increased blood pressure, altered heart rate variability, cardiac ischemia, and arrhythmias.<sup>15</sup> WHO and the American Heart Association have confirmed that a causal, quantitative relationship exists between exposure to high concentrations of PM<sub>2.5</sub> and increased mortality and morbidity.<sup>14,15</sup> Long-term exposure to high concentrations of PM<sub>2.5</sub> leads to premature deaths and reduces life expectancy within a population by several months to a few years without a discernable safe threshold.<sup>14,15</sup> Although WHO provides guideline values for PM<sub>2.5</sub> (annual mean concentrations of 10 µg/m<sup>3</sup> and 24 h mean concentrations of 25 µg/m<sup>3</sup>), the goal is to achieve the lowest concentration whenever possible due to the potential adverse health effects of PM<sub>2.5</sub>.<sup>14</sup>

The 2015 Greenpeace report indicated that only 6 of 31 provinces in the Mainland of China met the national standard of PM<sub>2.5</sub> (an annual average concentration less than 35 µg/m<sup>3</sup>).<sup>16</sup> It is noteworthy that this concentration is about 4 times greater than the recommendation (10 µg/m<sup>3</sup>) by WHO.<sup>14,16</sup> Furthermore, 293 of 366 Chinese cities failed to reach the standard (80.1%) and Beijing sat at No. 27 in the city rankings of levels of PM<sub>2.5</sub> air pollution with an annual average concentration of 80.4 µg/m<sup>3</sup>.<sup>16</sup> Because of this, Beijing and a few other northern cities suffered extremely bad air pollution, which caused a public outcry and led to the first ever announcement of a red alert for smog in the winter of 2015. In September 2016, an article published in *The Lancet* measured the health-related Sustainable Development Goals (SDGs) established by the United Nations General Assembly in 2015 for 188 countries.<sup>17</sup> Thirty-three health-related SDG indicators were analyzed and estimated based on the Global Burden of Diseases, Injuries, and Risk Factors Study 2015 from 1990 to 2015. Countries were ranked by the health-related SDG index (0–100) that represented all 33 health-related SDG indicators and had values computed as geometric mean of the rescaled indicators by SDG target. China was just ranked 92nd with an SDG index of 60, and of particular concern is the mean PM<sub>2.5</sub>, which received a value, the lowest of 25 among all 33 health-related SDG indicators. PM<sub>2.5</sub> has been one of the main threats to the sustainable development of China and will require nationwide efforts to resolve.

Moreover, in the context of such common and heavy air pollution, it is estimated that 1.6 million deaths per year (i.e., about 4000 deaths per day), could be attributed to PM<sub>2.5</sub> air pollution in China.<sup>18</sup> A recent report further analyzed the negative health effects of PM<sub>2.5</sub> in 74 leading Chinese cities based on the available monitoring data in 2013 and concluded that PM<sub>2.5</sub>-related deaths accounted for about 32% of all reported deaths in

the year of 2013, with a mortality rate of 1.9%.<sup>19</sup> Within the PM<sub>2.5</sub>-related deaths, the 3 main causes were cardiovascular and respiratory diseases and lung cancer. Furthermore, the report found that this PM<sub>2.5</sub>-related mortality rate was higher than those found in many other countries and the health risks of PM<sub>2.5</sub> might be even higher than those of smoking.

#### 4. PA and adverse health effects of PM<sub>2.5</sub>

Abundant health benefits of PA have been unanimously recognized globally. Thus, PA has been recommended globally to enhance health by governments and organizations. Regular PA can help to (1) control body weight; (2) reduce the risk of cardiovascular disease, type 2 diabetes and metabolic syndrome, and some cancers; (3) strengthen bones and muscles; (4) improve mental health and mood; (5) improve functional capacities and prevent falls; and (6) increase longevity.<sup>1,4</sup> However, exercising in air-polluted ambient environment can negate health benefits of PA. Adverse health effects of air pollution could be exacerbated due to the associated physiological stress in breathing, pollution dose, and nasal defense induced by exercise, especially for children and individuals with health conditions.<sup>7</sup> Although regular PA can improve some physiological mechanisms and adverse health outcomes that air pollution could exacerbate, it remains questionable whether the health benefits of exercise will adequately balance the adverse health effects of PM<sub>2.5</sub>.<sup>5,7</sup> Consequently, the public is advised to follow local air quality forecasts to avoid exercising outdoors when Air Quality Index (AQI) for PM is “unhealthy” and away from high traffic vehicular areas.<sup>7,15,20</sup> According to the *Technical Regulation on Ambient Air Quality Index (on trial)* edited by China’s Ministry of Environmental Protection, special populations (i.e., children and adolescents, elders, and patients with cardiovascular and respiratory diseases) should reduce long-time vigorous outdoor exercise during days of light pollution (defined as AQI 101–150).<sup>21</sup> The general population is also advised to reduce outdoor exercise appropriately in days of moderate pollution (AQI 151–200), while aforementioned special populations should avoid long-time vigorous outdoor exercise. In days of heavy pollution (AQI 201–300), special populations are recommended to stay indoors and completely stop exercising outdoors, while the general population should reduce outdoor exercise as much as possible. Ultimately, special populations are advised to stay indoors and avoid any physically-demanding activities on days of severe pollution (AQI > 300), while the general population should also avoid outdoor activities.

#### 5. Challenges and implications

In summary, current severe and nationwide PM<sub>2.5</sub> air pollution imposes a dilemma for China’s outdoor fitness and health promotion. PA and fitness promotion have been a focus in China’s national fitness program and the latest “Healthy China 2030” blueprint.<sup>9,11</sup> Increasing number of Chinese people are starting to participate in regular exercise, among which traditional outdoor activities are most popular. On the other hand, the ubiquitous PM<sub>2.5</sub> air pollution is also discouraging people from exercising outdoors, which could compromise PA and therefore

result in the loss of health benefits. Fortunately, creating a safe and better health environment was appropriately emphasized in the latest “Healthy China 2030” blueprint by modernizing techniques, equipment, and products of high environment implications and transforming industries of high pollutions.<sup>11</sup> It is envisaged that cities will enjoy good air quality during more than 80% of the year in 2020 with further improvement expected by 2030.<sup>11</sup> Successful policies in transport, urban planning, power generation, and industries can make a difference by reducing air pollution such as PM<sub>2.5</sub>.<sup>14</sup> For example from 2013 to 2015, air quality in the Beijing–Tianjin–Hebei area, Yangtze River Delta area, and Pearl River Delta area improved significantly and annual average PM<sub>2.5</sub> concentrations decreased largely owing to the strict implementation of the Air Pollution Prevention Plan and Heavy Air Pollution Emergency Response Plan.<sup>16</sup> Moreover, the improvement of PM<sub>2.5</sub> pollution could greatly reduce PM<sub>2.5</sub>-related all-cause mortality in Chinese people.<sup>19</sup> Thus, major policies on fighting air pollution should be strengthened and effectively implemented by both the central and local governments to solve the severe nationwide PM<sub>2.5</sub> air pollution and therefore create a safe and hospitable environment not only for PA but also for daily living.

On the other hand, there are still inconsistent research results on exercise in air-polluted environments.<sup>7</sup> It remains arguable whether exercise could balance the risk of air pollution. As a result, in the context of common PM<sub>2.5</sub> air pollution and national fitness and health promotion in China, studies on PA and air pollution are urgently needed to clarify the controversies to derive safe PA guidelines with respect to duration, intensity, and frequency in relation to PM<sub>2.5</sub> levels.

## 6. Conclusion

Nationwide PM<sub>2.5</sub> air pollution threatens the optimal implementation of China’s fitness and health promotion strategies. Policies on fighting air pollution should be strictly and unambiguously adopted by all levels of governments in China. Further research on PA and air pollution is urgently needed.

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## Authors’ contributions

JX and JZ conceived of the study, obtained research grants for this study, and drafted the manuscript; CG and JKWL helped to draft the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

## Competing interests

The authors declare that they have no competing interests.

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