Atmospheric Pollution Research 6 (2015) 618-625

Atmospheric Pollution Research

www.atmospolres.com

Particulate matter in ambient air and its association with alterations in lung functions and respiratory health problems among outdoor exercisers in National Capital Region, India

Chandrasekharan Nair Kesavachandran, Ritul Kamal, Vipin Bihari, Manoj Kumar Pathak, Amarnath Singh

Epidemiology Division, Council of Scientific and Industrial Research (CSIR)–Indian Institute of Toxicology Research, PB No 80, MG Marg, Lucknow 226 001, U.P., India

ABSTRACT

Regular exercise improves physiological processes and yields positive health outcomes. However, it is relatively less known that exposure to air pollution during outdoor exercises may actually exacerbate several health problems. The present cross–sectional study was undertaken to assess the particulate matter (PM) in the ambient air and its association with lung functions, pulse rate and respiratory problems among 378 outdoor exercisers in the National Capital Region (NCR), India. Lung functions were measured using a Spirometer (PIKO–1, PIKO–6) and respiratory problems were recorded through a questionnaire–based survey. Concentrations of particulate matter smaller than 2.5 and 1 microns were monitored at 10 locations across the study area using an online automated ambient air monitoring instrument–HAZ–DUST (EPAM–5000). Decline in Forced Expiratory Volume in 1 sec–FEV_1 (p<0.001) and Peak Expiratory Flow Rate–PEFR (p<0.001) was observed among the outdoor exercisers compared to the Indian reference values. Ambient air monitoring showed higher $PM_{2.5}$ concentrations at all the study locations compared to the recommended permissible levels for residential areas in India. Risk of FEV_1 (%) predicted cases with <80% showed an increase from 2.32% to 8.69% among the exercisers with respect to PM_1 concentration from lower to higher limit at the study locations. Similarly, PEFR showed an increased risk of predicted cases <80% from 0.78% to 2.91% among outside exercisers for lower to higher limit of PM_1 concentration. Cases with FEV_1 predicted <80% increased from 2.56% to 13.98% and for PEFR from 0.96% to 5.24% among outdoor exercisers for the corresponding lower to higher limits of $PM_{2.5}$ concentrations. The study demonstrates that outdoor exercisers in locations with high PM concentrations are at a risk of lung function impairment. These impairments are due to deposition of PM in the smaller and larger airways.

Keywords: *Particulate matter, outdoor exercisers, respiratory health*

doi: 10.5094/APR.2015.070

Corresponding Author:
Chandrasekharan Nair Kesavachandran
☎ : *+91-522-2620107*
🖷 : *+91-522-2628227*
✉ : *ckesavachandran@gmail.com*

Article History:
Received: 23 September 2014
Revised: 15 January 2015
Accepted: 15 January 2015

1. Introduction

Millions of people daily walk or run on streets or parks as a part of their routine exercise. Regular exercise is known to improve physiological processes and is considered key to good health. However, exposure to air pollution may cause a negative impact on health (Giles and Koehle, 2014). Data collected globally during 2002–2010 to track air pollution trends in 189 megacities indicated that Indian cities are among the most polluted ones (Alpert et al., 2012). The contention between need for routine exercise and exposure to high levels of airborne pollutants presents an interesting challenge of balancing benefits against detriments, particularly in areas of poor to very poor air quality (Giles and Koehle, 2014). There is good evidence of the effects of short–term exposure to PM_{10} on respiratory health, but for mortality, and especially as a consequence of long–term exposure, $PM_{2.5}$ is a stronger risk factor than the coarse fraction of PM_{10} (WHO Regional Office for Europe, 2013). All–cause daily mortality is estimated to increase by 0.2–0.6% per 10 μg/m^3 of PM_{10} (WHO Regional Office for Europe, 2006; Samoli et al., 2008). Long–term exposure to $PM_{2.5}$ is associated with an increase in the long–term risk of cardiopulmonary mortality by 6–13% per 10 μg/m^3 of $PM_{2.5}$ (Pope et al., 2002; Beelen et al., 2008; Krewski et al., 2009).

Physical inactivity poses a significant health risk to individuals as it increases the likelihood of developing heart disease, type 2 diabetes mellitus, cancer, and stroke (Blair, 2009; Williams, 2009). It is estimated that physical inactivity is the fourth most common cause of mortality in humans and contributes to 3.2 million annual deaths (WHO, 2009). Regular physical activities of moderate intensity like brisk walking can decrease the risk of non–communicable diseases (Willet et al., 2006). However, many of the most accessible forms of exercise, such as walking, cycling, and running often occur outdoors (Giles and Koehle, 2014). In many modern societies, jogging has become increasingly popular (Aydin et al., 2014). In India, outdoor exercises like walking, jogging and cycling are undertaken by several citizens during the morning and evening hours. Susceptible groups with pre–existing lung or heart disease, as well as elderly people and children, are particularly vulnerable to PM effects (WHO Regional Office for Europe, 2013).

A recent study conducted in Central India shows that the annual mean $PM_{2.5}$ concentration is three times higher than the National Ambient Air Quality Standards of India (NAAQS) (Deshmukh et al., 2013a). Similar higher concentration was also observed in the National Capital Region (NCR), India (Kesavachandran et al., 2013). There is no evidence of a safe level of exposure or a threshold below which no adverse health effects occur (WHO Regional Office for Europe, 2013). Also, higher concentrations of PM_1, $PM_{2.5}$ and $PM_{2.5–10}$ were found during winter in Central India due to enormous biomass burning, especially during the night time (Deshmukh et al., 2013a). This was suggested to be associated with the use of combustible goods like fire wood and dung cake and temperature inversion in the open space by the local people to keep them warm. Lower concen-

trations were observed during monsoon due to high precipitation (Deshmukh et al., 2010; Deshmukh et al., 2013a).

In another study, higher nasal resistance was observed among outdoor runners during the times of heavy traffic as compared to runners at locations away from the traffic (Aydin et al., 2014). PM exposure can lead to oxidative stress, increased bronchial responsiveness, increased airway resistance, and increased number of airway inflammatory cells, each of which may impair lung function (Holgate et al., 2003; Kelly, 2003). The assumption that the high PM concentrations in the atmosphere can put outdoor exercisers at high risk of lung ailments prompted us to take up this study. The present cross–sectional study aims at correlating the relationship between PM in the ambient air and its association with lung functions, pulse rate and respiratory problems among outdoor exercisers in the National Capital Region (NCR), India. To the best of our knowledge, this is the first report on the association between PM concentration and respiratory health risks among outside exercisers in India.

2. Materials and Methods

2.1. Study design, study subjects, and the study location

A cross–sectional study was conducted among 378 residents who regularly exercise outdoors (i.e., walking, running etc.) and 163 matched non–exercisers who do not do any outdoor exercise. Both the groups lived in the National Capital Region, India. National Capital Region (NCR) includes areas at the outskirts of New Delhi and can be considered as a semi–urbanized part of the megacity of Delhi. Ten study locations were randomly identified from two regions of NCR, namely NOIDA (Figure 1) and Gurgaon (Figure 2). The main sources of pollution in these areas are the large–scale infrastructural development activities like construction of roads and houses, moderate traffic, and agricultural dust. A respiratory health survey was conducted through a questionnaire to assess the lung–related problems experienced by the study subjects. All the subjects participating in the study worked and resided within 3 km of the air quality sampling site. This approach ensured that the air quality levels represented the actual exposure to PM for the participants. Also, the study subjects conducted outdoor exercises within this 3 km radius of the sampling sites. Those subjects taking any medications were excluded from the study. The study participants were agricultural laborers, anganwadi (child care) workers, beauty parlor workers, haircutting saloon workers, small business proprietors, shop owners and salesmen, contract manual laborers, dairy and livestock workers, gardeners, health care workers, housewives, teachers, and students.

2.2. Ambient air monitoring for particulate matter

Air monitoring for PM concentrations ($PM_{2.5}$, PM_1) was conducted at each of the 10 study location for 8 h per day. For ideal correlation, the day of the monitoring and the day of the health survey were kept the same. Air monitoring was done using an online automated ambient air monitoring instrument, HAZ–DUST (EPAM–5000, Environmental Devices Corporation, USA) at the study sites. The HAZ–DUST EPAM–5000 is a portable microprocessor–based particulate monitor using the light scattering method suitable for ambient air quality investigations. Interchangeable size–selective impactors monitor $PM_{2.5}$ and $PM_{1.0}$. The performance profile of the instrument includes sensing range (0.001 to 20 mg/m^3), particle size range (0.1 to 100 µm) and sampling flow rate of 1–4 L/min. Ambient air monitoring was selected at a height of 10 m from the ground and placed on the roof of nearby houses, which were about 200 m away from traffic intersections. Sampling sites for PM measurements in ambient air were selected on a random basis at the study locations.

Quality assurance/quality control procedures were maintained according to the instruction manual of the instrument. Manual–zero sets the measurement baseline of the instrument to zero mg/m^3. The manual–zero check was performed prior to beginning a new set of measurements. Flow meter was used to ensure the flow rate of 4 L/min before each sampling procedure. The same monitor was used at all the locations. The study was conducted during the months of July to September between 2008 and 2010.

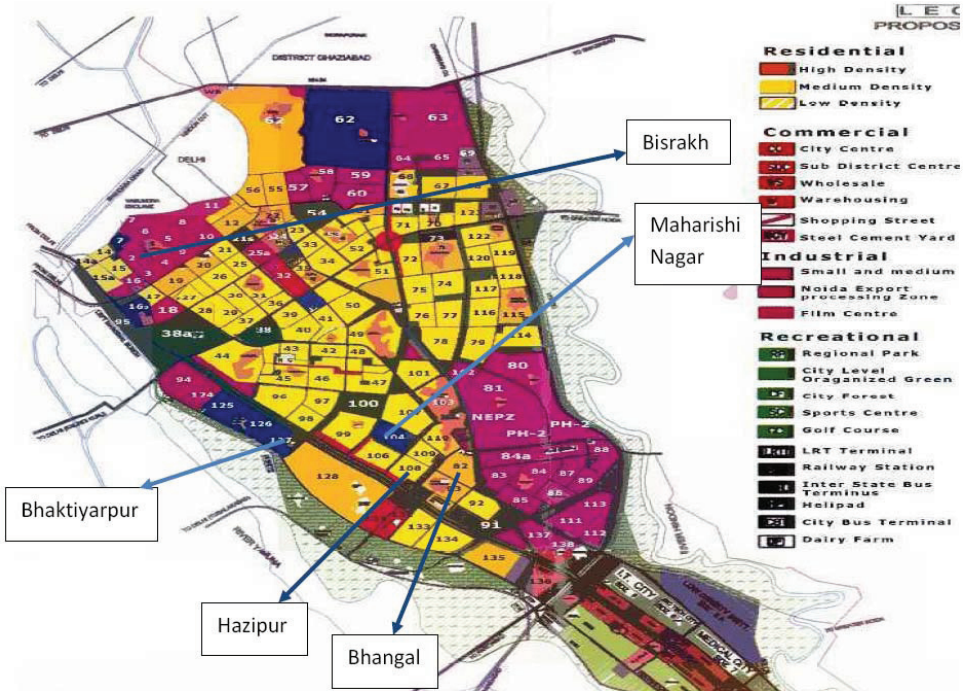

Figure 1. *Study locations at NCR region–NOIDA.*