Association of Ambient Air Quality with Male's Pulmonary Function in Kolkata City, India

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ABSTRACT

Background

Kolkata is one of the polluted metropolitan cities in India where health effects of air pollution are raising serious concern.

Objectives

Purpose of the present study was to analyze association between levels of air pollutants and pulmonary function of adult males living in two different air pollutant zones of Kolkata.

Methods

Air pollution data of two ambient air quality monitoring stations located at Rabindrabharati and Victoria Memorial was collected from West Bengal Pollution Control Board, Kolkata for the period from January to March 2012. Study was conducted on 200 males (17-22 yrs), subdivided into two groups from living within 3 km radius of that two monitoring stations. They were investigated for their spirometric lung functions following method and technique recommended by American Thoracic Society. Results were expressed as mean ± SD and independent samples T test was conducted to compare between groups.

Results

PM10, SO_2 concentrations were significantly higher in Rabindrabharati zone, whereas no significant differences were noted in NO_2 and CO concentrations though values were higher at Rabindrabharati than Victoria Memorial. FVC, FEV_1, $FEF_{25-75\%}$, MVV were significantly lower in males of Rabindrabharati zone.

Conclusion

Exposure to high air pollutant concentration might be associated with reduced pulmonary function in adult males.

KEY WORDS

Air pollution, FVC, FEV_1, $FEF_{25-75\%}$, MVV

INTRODUCTION

Air pollution has become one of the major health hazards in people living in megacities. Unfavorable effects on the body from pollutants are multi factorial, with acute or chronic exposures including cardiovascular disease and damaging pulmonary function.[1] In India, along with the concentration of the population and production in large cities, air pollution is currently causing a serious problem. The pollution level of Kolkata, the capital of West Bengal is increasing day by day. This is a real threat to Kolkata and the citizens of Kolkata and people should be aware of that. Automobiles and road traffic produce suspended particulate matter (SPM), oxides of sulphur (SOx), oxides of nitrogen (NOx), and carbon monoxide (CO), which makes adverse health effects on the exposed population.

Many studies revealed the association of PM10 exposure with decreased lung function. Increase in SO_2 concentration results in reduction of FVC and FEV1.[2-4] Studies in United States by Ferris and Shy et al.[5,6] have shown that vital capacity (VC) and forced expiratory volume (FEVt) were both reduced in children in areas of heavy pollution, and in England, Holland et al.[7] has reported reduced peak expiratory flow rates (PEFR) in adolescents living in areas of high pollution.

Other studies on the influence of air pollution on children's pulmonary function reported that in areas of high concentration of nitric oxide,[8,9] the values of children's pulmonary function parameters are low. Several studies have shown an association between exposure to vehicular pollution and adverse effects on respiratory symptoms and pulmonary function,[10,11] whereas, others failed to find such an association.[12] In this way, the results of studies on the effects of air pollution are not conclusive. So extensive research is needed to investigate the effects of air pollution in non-occupationally exposed subjects specially. In the present study an attempt had been made to evaluate the effect of air pollution on pulmonary function (FVC, FEV_1, $FEF_{25-75\%}$, MVV) of adult male residing in two different zones of Kolkata exposed to two different level of air pollution.

METHODS

Selection of place:

Study areas were chosen from Kolkata, West Bengal. The air pollution data of the period from January 2012 to March 2012 was collected from West Bengal Pollution Control Board (WBPCB), Kolkata (www.wbpcb.gov.in) which included the pollutant levels at the two ambient air quality monitoring stations located at Rabindrabharati (North Kolkata) and Victoria Memorial (Central Kolkata). The major air pollutants monitored at these stations were particulate matter (PM10), sulphur dioxide (SO_2), nitrogen di dioxide (NO_2) and carbon mono oxide (CO).

Subjects:

Study was conducted on two hundred males of the age range 17-22 years, subdivided into two groups - living within 3 km radius of that two monitoring stations. All the participants (subjects) were residents in those two zones for a minimum period of three years. Subjects with acute or chronic respiratory illness, past or present history of smoking, systemic illness and on chronic medication were excluded from the study. All institutional policies concerning the human subjects in research were followed. Ethical approval was taken from the competent authority.

Data Collection:

The data collected included anthropometric parameters and measurement of pulmonary function. All the participants were subjected for anthropometric and lung function tests during the period January-March, 2012.

Anthropometric parameters-

Standing height in cm was measured with shoes removed, feet together. Weight in kg was measured with shoes and Jackets removed.

Body surface area (BSA) and body mass index (BMI) were calculated by Du-Bois and Du-Bois Formula and Meltzer's equation respectively.[13,14]

Determination of Lung function tests -

During the testing, the subjects were observed for coughing or wheezing. All tests were done in the standing position and a noseclip was used. Most of the tests were done between 11:00 A.M. and 3:00 P.M. The spirometry was performed with a modified water-sealed Toshiwal Expirograph (9l capacity) with sodalime cannister removed. The spirometer met the technical specifications of the American Thoracic Society.[15] The spirometric measures consisted of forced vital capacity (FVC), forced expiratory volume in first one second (FEV_1), forced mid expiratory flow ($FEF_{25-75\%}$), maximum voluntary ventilation (MVV). The terminology of the ventilatory function tests is in accordance with the recommendations of the American Thoracic Society.[15] For each subject, at least three satisfactory spirograms were obtained. Performance of spirometry and selection of the best spirogram were made according to the method outlined by American Thoracic Society. Measurement and calculations of spirometric results were made according to the techniques recommended by Kory et al.[16] and Intermountain Thoracic Society.[17] The volumes and flow rates were corrected to body temperature and pressure, saturated with water vapour (BTPS). The spirometer was calibrated every week by using Palmer respiratory hand pump.

Statistical Analysis:

All the values are expressed as Mean ± Standard Deviations (SD). Statistical package for the social science (SPSS) version

20 was used for analysis. Independent samples T test were adopted for statistical analysis of the data

RESULTS

The ambient air quality data (Mean ± SD) as reported by WBPCB in the two areas of Kolkata are shown in table 1. Values of PM10 of both regions were much more than the national ambient air quality standards (http://cpcb.nic.in/National_Ambient_Air_Quality_Standards.php), while SO_2 and CO were within the standards. On the other hand, NO_2 of Rabindrabharati zone showed higher value than the standard but this was lower in other zone. Comparison of the two ambient air quality data revealed that PM10 and SO_2 were significantly higher ($p<0.01$) in Rabindrabharati than Victoria Memorial zone, whereas no significant difference was obtained in NO_2 and CO values, although, these were also higher in Rabindrabharati area.

Table 1. Level of significance of difference in Air Pollutant concentration between two zones of Kolkata

Air Pollutant	National Ambient Air Quality Standard	Rabindrabharati	Victoria Memorial	'T' – test
PM10(µg/m³)	100	184.03±53.76	125.27 ± 63.59	p<0.01
SO_2 (µg/m³)	80	28.34±16.27	7.15 ± 4.20	p<0.01
NO_2 (µg/m³)	80	81.60±49.16	75.02 ± 43.15	NS
CO (mg/m³)	04	1.6±1.8	1.4±0.8	NS

The anthropometric parameters and pulmonary function test values of the adult males residing in the two zones of Kolkata are shown in table 2. No statistical difference was observed between the groups in anthropometric parameters. But FVC, FEV_1, $FEF_{25-75\%}$, MVV were significantly higher ($p<0.01$) in males of Victoria Memorial zone compared to Rabindrabharati zone.

Table 2. Comparison of anthropometric parameters and pulmonary function tests between adult males from two zones.

Parameters	Adult Male		't' – Test
	Rabindrabharati (n =100)	Victoria Memorial (n=100)	
Height (cm)	165.56±5.80	164.61±5.61	NS
Weight (kg)	56.34 ± 4.61	56.03 ± 4.39	NS
BSA (m²)	1.62 ± 0.06	1.61 ± 0.08	NS
BMI (kg/m²)	20.66 ± 2.44	20.68 ± 1.40	NS
FVC (l)	165.56 ± 5.80	164.61 ± 5.61	p<0.01
FEV_1(l)	3.08 ± 0.37	3.71 ± 0.33	p<0.01
$FEF_{25-75\%}$ (l/min)	208 ± 41.8	276 ± 45.1	p<0.01
MVV (l/min)	119.4 ± 16.1	138.6 ± 17.1	p<0.01

NS= Not Significant

DISCUSSION

Pulmonary Function testing measures the function of lung capacity, lung and chest wall mechanics to determine whether or not the patient has a lung problem. Vital capacity is an important index in pulmonary function.[18] The parameters of lung function in an apparently healthy population may be influenced by socioeconomic and nutritional status, physical activity patterns, atmospheric pollution levels,[19-22] and other factors like age, sex, height, weight etc.[23,24] Literature suggests the adverse effects of long-term exposure to ambient air pollution on lung function.[25,26] A work conducted in Japan demonstrated reduced pulmonary functions among children in areas of heavy pollution.[27] Many studies also reported the consequences of outdoor air pollution both from acute and long term exposure, contribution to risk of respiratory symptoms, decreased lung function, increased heart disease, as well as increasing mortality.[28,29]

This study demonstrates that values for FVC, FEV_1, $FEF_{25-75\%}$, MVV are significantly lower among males of Rabindrabharati zone, when compared with a similar sample of males at Victoria Memorial zone. Similarly, levels of particulates and chemicals which are known contributors of air pollution are considerably higher in Rabindrabharati than Victoria Memorial zone. However, the purpose of this work was to determine the effects of air pollutants on people residing in an area of high air pollutants. The present study also revealed the fact of adverse effect on lung function of adult male. Sedentary males from the two regions were from the same socio-economic status. Results showed that there were no significant difference in their age, height, weight, BSA and BMI. In spite of that, FVC, FEV_1, $FEF_{25-75\%}$, MVV were lower for male from Rabindrabharati zone. Hence, it appears that environmental aspects might be the major determining factor for the difference in lung function parameters, because, one group was from Victoria Memorial zone where the pollutant level was low and the other was from Rabindrabharati zone where the air pollutant level was high. Automobile exhaust is a vital cause of pollution in urban areas. A relationship between the prevalence of certain symptoms and household location with respect to distances from roadside has been reported.[30] A study by Scarlett et al,[31] exposed statistically significant adverse effect of airborne respirable particulate matter, measured as PM10, on lung function in children in south-east England. Long term NO exposure also causes increase in respiratory symptoms and decreased lung function parameters. According to the study by Peters et al,[8] PM10, PM2.5, and NO_2 were significantly associated with lower FVC, FEV_1, and maximal midexpiratory flow (MMEF) in Southern California public school children. Chang et al,[3] concluded that the short-term exposure to O_3 and PM10 was associated with reducing FVC and FEV_1 in adolescent school students in Taipei city, Taiwan. Decrement in lung function indices (i.e. FVC and/or FEV_1) due to increased concentrations of RSPM and CO_2 during winter period has

also been observed in the women of Delhi.[32] Exposure to air pollution mainly occurs by inhalational route, and hence airway epithelium is first to be affected. The airway epithelium in response, releases reactive mediators, which play an important role in the inflammatory response.[33] PMs have been reported to be associated with increased risk of pulmonary diseases and detrimental outcomes related to the cardiovascular system, including altered vessel functions, lung cancer, leukemia, lymphoma and central nervous system tumors.[34] Depending on their size, they can lodge in the respiratory tract and even penetrate pulmonary tissue with long-term cumulative adverse effects on lung development in children from the age of 10 to 18 years, leading to clinically significant deficits in attained FEV1 as children reach adulthood.[35] Chattopadhyay et al,[36] found that a number of school students of Kolkata city are having different types of respiratory symptoms and concluded that long-term effect of exposure into such environment may develop lung functional impairments.

Some studies have reported the increases in respiratory and cardiovascular problems at outdoor pollutant levels well below the standards set by such agencies as the US EPA (United States Environmental Protection Agency) and WHO.[37] Adverse effects on respiratory health are not limited to high concentrations of air pollutants, but have also been observed at relatively low concentrations.[38] Deleterious health effects may result from exposure to pollutants at concentrations that are lower than recommended standards. Indeed, research to date has failed to establish a "threshold" limit for which there is no adverse health effect.[39] A cross-sectional study of respiratory symptoms and repeated pulmonary function testing in three zones from two geographically different areas in Tokyo, revealed that exposure to automobile exhaust may be associated with respiratory symptoms.[30] Another study by Sekine et al,[40] revealed the long term effects of exposure to automobile exhaust on the pulmonary function of female adults in Tokyo, Japan. So, in our study the lower pulmonary function i.e. decreased values of FVC, FEV_1, $FEF_{25-75\%}$, MVV sedentary adult male of Rabindrabharati zone might be due the impact of higher air pollutants which demands further investigation. So these data further support the possibility that environmental factors during the early years of life can cause adverse effects which may produce either temporary reduction in pulmonary efficiency or permanent debilitating pulmonary conditions.

Limitations of study -

a. The study is limited to a particular age group.

b. The study is limited to only the no-smoker subjects.

c. Although the subjects were from a comparable socio-economic status, household pollution exposure was not considered for individual subject.

CONCLUSION

The present finding provides supports that exposure to high air pollutant concentration might be cause of decreased pulmonary function of adult male comparing to those who were exposed to less air pollution. However, this area of research needs further investigations.

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