

Impact of Chronic Air Pollution Exposure on Pulmonary Function in Healthy Nonsmoker Young Men from Two Different Areas of Kanpur City

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ABSTRACT

Background: Air pollution is one of the major problem faced in developing countries like India. Chronic exposure to air pollutants can leads to hampered day today activity and increased visit to clinics. The pollutant PM10 (particulate matter size less than 10 μ) especially a risk factor associated with decreased lung functions. The effect of chronic exposure of different concentration of air pollution level on pulmonary function test is still lacking in India especially in Kanpur, a highly polluted city of U.P., India.

Aims & Objective: The present study was conducted to evaluate the impact of chronic exposure of air pollution on lung functions in two differently polluted areas.

Materials and methods: One hundred twenty male subjects, in age group of 18 to 30 years from two polluted area of Kanpur, India were participated in the study. Anthropometric data were taken. Pulmonary function test was conducted in standing position. Pollution data of study period was taken from Central pollution control board and compared with the National ambient air quality standard. All data presented as mean $\pm$ SD and analysed by independent sample t test by using SPSS version 15.

Results: The anthropometric data were statistically not significant in two areas. Forced vital capacity and Forced expiratory flow 25-75 % were statistically significantly different ($p < 0.05$) and Peak expiratory flow and Vital capacity were also significantly different in two areas.

Conclusion: The long term exposure of pollutant PM10 could reduce the forced vital capacity, Forced expiratory flow 25-75 %, Vital capacity and peak expiratory flow. Thus every attempt should be made towards lowering air pollution like alternate fuels such as CNG or hybrid technology.

KEY WORDS: Air Pollution; Pulmonary Function Test; Airborne Particulate Matter

INTRODUCTION

Short term and long term air pollution exposure has been associated to various adverse health effects.^[1] That includes hampered day today activity, increased visit to physician or hospitals for exacerbation of pre-existing asthma and chronic obstructive pulmonary disorder, increased susceptibility to infection and other respiratory illnesses.^[2] The histo-pathological changes in adults exposed to high levels of urban air pollution have also been observed.^[3] The airborne particulates especially PM₁₀ (particulate matter size less than 10 µ), nitrogen dioxide (NO₂) and sulphur dioxide (SO₂) are risk factors associated with lung function decrease.^[4]

According to central pollution control board (CPCB) 2011 national summary report^[5]: Kanpur, the largest industrial city of Uttar Pradesh having the area of 230 Km², a dense population of 2.57 million (2001 census), and a vehicle population of 0.59 million in 2007. Kanpur shows the highest concentrations of PM₁₀, where standard is exceeded by more than three times during 2000-2006. If no action is taken up to 2017 and city will have unbridled growth, not only the entire city will exceed the air quality standards, nearly 50 km² (nearly 1 /5th of city) areas may have air quality much above 500 µg/m³ (max 24- hour) for PM₁₀.

Literature has shown adverse effects of ambient air pollution exposure on various physical disorders in adolescent. However, the data regarding the chronic exposure of different concentration of air pollution level is still lacking in India except a few study like in Delhi^[6] and Lucknow.^[7] In Kanpur, a highly polluted city of U.P. no such study is known in our best knowledge.

Our aim of study to evaluate the impact of air pollution on pulmonary function tests in younger, non-smoking healthy men of two different levels of air pollution exposure. We choose younger subjects because they are the core of a national economy, health etc.

MATERIALS AND METHODS

The present study was conducted in two differently polluted Industrial areas (Fazal ganj and Jajmau) in the Kanpur city U.P., India on 60 subjects from each area (n=120). The ambient air quality data of these areas were taken from the central pollution control board.^[8] Approval of Institute's ethical committee was obtained. Subjects were taken randomly. Inclusion criteria were as follows: subject's age between 18 to 30 years, male, must be a resident of that area for at least past 5 years. Exclusion criteria for the study were as follows: Smokers, any major chest or spine deformity/surgery, known case of any major respiratory disease like bronchial asthma, chronic obstructive pulmonary disorder, and Industrial workers. Detailed information was collected on pre-designed proforma. The complete general, anthropometric and systemic examinations were carried out. Subjects were properly explained about the aim, objective, methodology, expected outcome and implications prior to commencement of this research study.

Pulmonary function test (PFT), carried out with the help of computerized spirometer. It was a non-invasive and quite accurate method. The instrument used was Spiroband-G. Age, height and weight of subjects were entered in spirometer before taking data. The data was taken in standing posture. The proper demonstration of instrument and procedure were given before the commencement of the study. The subjects were asked to inspire slowly as much air as possible and then expire all of the air as fast as possible; nose must be well fitted to preclude the possibility of losing expired air in to the atmosphere. Three such tests were performed and subjects were coached to improve the efforts. The highest value data set was used for statistical analysis. The following parameters were recorded: Respiratory rate (RR), Tidal volume (TV), Forced vital capacity (FVC), Forced expiratory volume in 1 sec (FEV₁), FEV₁/FVC ratio, Peak expiratory flow (PEF), Forced expiratory flow at 25-75% of volume as a percentage of VC (FEF 2575), Vital capacity (VC). The recording of Maximum voluntary ventilation

(MVV) was done by asking the subject to make series of forced inspirations & expirations breathing as deep & fast as possible for at least 15seconds.

Ambient Air Quality Data Collection

Data was collected from central pollution control board. [15] Study period was from Jan 2009 to Dec 2009. Measured pollutants were sulphur dioxide (SO₂), nitrogen dioxide (NO₂) and respirable suspended particulate matter (RSPM or PM₁₀). Data were measured 24 hourly averaged concentrations of these pollutants. These data were compared with the National Ambient Air Quality Standards provided by central pollution control board (notification no. B-29016/20/90/PCI-L).^[9]

Statistical Analysis

All data presented as mean $\pm$ SD. The data were analysed for normal distribution and descriptive statistics were used. The all the data were further analyzed by "Independent-sample t test" by using SPSS version 15. A p value of <0.05 was considered statistically significant.

RESULTS

The difference between age, height, weight, BMI and chest circumference were statistically not significant between the subjects of two areas thus the two groups were comparable (Table - 1). The comparison was made between the two differently polluted area's healthy, non-smoking

men. It was observed that there was statistically significant ($p<0.05$) decrease in Forced vital capacity (FVC) and Forced expiratory flow at 25-75% of volume as a percentage of VC (FEF 2575) in Area II compared to the Area I, also Peak expiratory flow (PEF), and Vital capacity (VC) were also significantly different ($p<0.01$). While the difference in Respiratory rate (RR), Tidal volume (TV), Forced expiratory volume in 1 sec (FEV1), FEV1/FVC ratio and Maximum voluntary ventilation (MVV) was statistically not significant between the areas. (Table - 2)

Table-1: Anthropometric Parameters (Values expressed in Mean $\pm$ SD)

	Area I (n=60)	Area II (n=60)	P value
Age (year)	24.35 $\pm$ 2.62	24.38 $\pm$ 3.23	0.951
Height (cm)	172.98 $\pm$ 3.12	173.27 $\pm$ 3.22	0.625
Weight (Kg)	63.03 $\pm$ 5.6	64.25 $\pm$ 4.95	0.210
BMI	21.09 $\pm$ 2.10	21.44 $\pm$ 2.09	0.357
Chest Circumference (cm)	85.92 $\pm$ 9.67	86.58 $\pm$ 8.43	0.688

Table-2: Flow Rates and Lung Volumes in Subjects from Two Areas of Kanpur (Values expressed in Mean $\pm$ SD)

	Area I	Area II	P value
RR (/min)	17.17 $\pm$ 4.26	16.28 $\pm$ 2.39	0.164
TV (Litre)	0.42 $\pm$ 0.07	0.43 $\pm$ 0.05	0.300
RMV (Litre)	5.69 $\pm$ 0.56	5.82 $\pm$ 0.82	0.283
FVC (Litre)	4.48 $\pm$ 0.43	4.32 $\pm$ 0.45	0.053
FEV1 (Litre)	3.83 $\pm$ 0.55	3.73 $\pm$ 0.58	0.359
FEV1/FVC ratio	0.86 $\pm$ 0.16	0.87 $\pm$ 0.17	0.733
PEF (Litre/sec)	7.56 $\pm$ 1.15	8.06 $\pm$ 1.15	0.019
FEF 2575 (Litre/sec)	4.13 $\pm$ 0.62	4.34 $\pm$ 0.55	0.052
VC (Litre)	3.78 $\pm$ 0.68	4.08 $\pm$ 0.56	0.012
MVV (Litre)	112.99 $\pm$ 13.23	117.18 $\pm$ 18.29	0.154

Table-3: National Ambient Air Quality Standards

Pollutant	Time weighted average	Industrial, Residential, Rural and other area	Ecologically sensitive area	Methods of measurement
Sulphur dioxide (SO ₂), $\mu\text{g}/\text{m}^3$	Annual 24 hours	50 80	20 80	- Improved West and Gaeke - ultraviolet fluorescence
Nitrogen dioxide (NO ₂), $\mu\text{g}/\text{m}^3$	Annual 24 hours	40 80	30 80	- Modified Jacob & Hochheiser - Chemiluminescence
Particulate matter (size $< 10 \mu\text{g}$) or PM ₁₀ $\mu\text{g}/\text{m}^3$	Annual 24 hours	60 100	60 100	- Gravimetric - TOEM - Beta attenuation

Data was collected from Jan 2009 to Dec 2009. During this period, 24 hourly averaged pollutants concentration varies. For SO₂ from 5.7 to 11.2 µg/m³ and 5.3 to 13.6 µg/m³; for NO₂ from 24.4 to 41.2 µg/m³ and 21.1 to 41.4 µg/m³ while RSPM (PM₁₀) concentration varies from 191 to 279 µg/m³ and 144 to 265 µg/m³, at both areas; Fazal ganj and Jajmau respectively. On comparison with National Ambient Air Quality Standards, RSPM level was very high at both study sites while level of other pollutants like SO₂, nitrogen dioxide (NO₂) were within normal limits of National Ambient Air Quality Standards (Table - 3). While comparing both areas, we observed a highly significant difference ($p < 0.001$) for SO₂, NO₂ and PM₁₀. (Table - 4)

Table-4: Mean and S.D. of Ambient Air Quality Data in Two Different Areas of Kanpur City (Average Annualized Values)

	Area I (mean ± SD)	Area II (mean ± SD)	P value
SO ₂ (µg/m ³)	8.08 ± 1.06	7.44 ± 1.42	0.001
NO ₂ (µg/m ³)	33.36 ± 3.90	29.86 ± 5.12	0.000
RSPM or PM ₁₀ (µg/m ³)	231.72 ± 16.35	200.96 ± 28.45	0.000

DISCUSSION

This study confirmed that the air pollution levels, affecting the pulmonary function parameters in healthy, non-smoking, young men. The results clearly showed a higher airflow limitation with higher air pollution. Similar results observed in Poland [10] while in Delhi (India) a study on five areas showed no significant difference but the trend is towards lower values.[6] The reason why no differences in pulmonary function between different zones in Delhi may have resulted by either due to almost equal air pollution levels in different zone or some other unknown potential confounders. Also a cohort of school children was analyzed by Dockery et al[11] in the Six Cities Study, finding no effects of air pollution on lung function. Although they suggest that children with hyperreactive airways may be particularly susceptible to other respiratory symptoms when exposed to pollutants.

Chronic exposure of air pollutant affecting the respiratory health and contributes to

development of respiratory symptoms, decreased lung function, increased hospital admissions.[12, 13] A study of respiratory effects of relocating to areas of differing air pollution levels in children[14] reported the reduction in annual respiratory growth rates with increased pollution exposure that may reduce the level of lung function attained and lead ultimately to an increased risk of respiratory events in adulthood. This finding is consistent with our study results, showed a statistically significant decrease in pulmonary function parameters in highly polluted area in comparison to less polluted area. Air pollutant, mainly sulphur oxides, nitrogen oxides and PM₁₀ (particulate matter with a diameter of less than 10 µm) causes air flow limitation. Also, it exaggerates existing allergic disease like asthma, additionally stimulating the reconstruction of the lung tissue and causing its structural changes / remodeling.[15, 16] Decrease of flow rates especially FEF 25-75% is the first measurable sign of the initiation of bronchitis and lung obstructive disease mainly affecting smaller airways.[6] The FEF 25-75% is statistically significantly reduced in highly polluted area than in less polluted area residents. A study by Jendrychowski and Flankl[17] showed a strong correlation between the amount of coughed-up secretion and the concentration of basic air pollution in children living in different environments. Children who lived in regions with a high air pollution level had a significant increase of frequency of wheezing suggesting the obstruction.

Frye C et al[18] and Avol et al[14] reported an increased growth in lung function in children from southern California who had moved to areas with lower PM₁₀ and a decreased growth in lung function in subjects who moved to communities with a higher PM₁₀. This supports our view that by reducing air pollution there is improvement in lung function

Sharma M et al[19] studied effects of particulate air pollution on the respiratory health of subjects who live in three areas in Kanpur. They estimated that an increase of the pollutant PM₁₀ could reduce the mean peak expiratory flow rate,

forced vital capacity and forced expiratory volume in 1 s values. This further confirms our results.

Limitations and Strength

The sample size was small thus warranted a larger study. Also we had taken only male subjects so the difference of effect in sex is not evaluated as shown by various studies like by Peters et al.^[20]

On the other hand, we had taken the initiate to take such type study in very highly polluted Kanpur city in which these kind of analysis was not done yet. In addition, we excluded all persons that had moved within the last 5 years thus ensuring that the subjects were chronically exposed to the air pollution measured by the health authorities. We also had taken age, height, and weight and chest circumference to avoid any confounding factor affecting.

CONCLUSION

Our study had a unique opportunity to investigate the chronic effect of different level of air pollution on pulmonary function parameters in healthy non-smoker men. The long term exposure of the pollutant PM₁₀ could reduce the forced vital capacity and FEF 2575, vital capacity and the peak expiratory flow rate.

To improve quality of life, all attempts should be made to reduce air pollution. This is further supported by Frye C et al^[18] suggesting reduction of air pollution in a short time period may improve children's lung function and also by study of Edward L et al^[14] showed decreased lung growth of children in highly air polluted areas. Also, further intensive research effort in this area of environmental health is needed by various possible approaches.

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