

Effect of ambient air quality on functional exercise capacity and pulmonary function in healthy young adults

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Abstract

Introduction and Objective: Air pollution exposure contributes to all-cause morbidity and mortality. Epidemiological studies indicate that short-term exposure to increase in fine particulate matter (PM) concentration triggers negative health effects. PM can penetrate into and retain in the walls of small airways leading to generation of free radicals and triggering intracellular oxidative stress which can cause lung tissue damage. The objective of the present study was to analyze the effect of short-term ambient air pollution on functional exercise capacity and pulmonary function.

Materials and Methods: The study was conducted on 100 MBBS students both male and female in the Department of Physiology, ESIC Medical College, Faridabad, from June 2018 to August 2018. FEV₁% predicted and 6 minute-walk distance (6MWD) of all the subjects were recorded on two occasions, once when the air quality was poor and second time when air quality was satisfactory. Air Quality Index (AQI) was noted from the official website of Central Pollution Control Board (CPCB). Statistical analysis was done by applying paired t-test.

Results: The mean AQI on bad air quality days was 288.76±44.46 and on satisfactory air quality days was 86.47±8.17. A significant improvement in FEV₁% predicted and 6MWD with the improvement in air quality was seen in only 2% and 11% subjects respectively.

Conclusion: Short term ambient air pollution does not affect functional exercise capacity and pulmonary function in young healthy adults. However repeated spells may produce adverse health effects.

Keywords: Air quality index, FEV₁% predicted, 6-min walk test.

Introduction

Clean air is the foremost requirement for human well-being. Air pollution is the contamination of environment by chemical, physical or biological agents that alter the natural characteristics of the environment. Ambient air pollution is largely a result of combustion of fossil fuels that are used in transportation, power generation and industrial sector. Household air pollution also known as Indoor Air Pollution (IAP) is a serious concern in rural areas, as majority of rural population continues to depend on traditional biomass for cooking and space heating which lead to high levels of IAP.

Exposure to particulate air pollution has been associated with increase in cardiovascular and respiratory diseases.^{1,2} Throughout the world about 7 million people died prematurely in 2012 due to air pollution, of which 3.7 million deaths occurred due to outdoor air pollution.³ In India air pollution has been identified as a national problem since it is the fifth biggest cause of mortality.⁴

The impact of chronic exposure to air pollution on pulmonary function has been widely studied and established.⁵ The effect of short term exposure to air pollution on pulmonary function has also been studied but predominantly in vulnerable subgroups such as children and asthmatics.⁶ In the last few years air quality has deteriorated to alarming levels in Delhi and NCR. Central Pollution Control Board along with State Pollution Control Boards has been operating National air monitoring program covering 240 cities of the country. In metro cities, continuous monitoring systems provide data on real time

basis. AQI is a tool for effective dissemination of information about air quality to people. It considers eight pollutants (PM₁₀, PM_{2.5}, NO₂, SO₂, CO, O₃, NH₃, Pb) to monitor the general state of air quality. Accordingly there are six AQI categories namely- Good (0-50), Satisfactory (51-100), Moderate (101-200), Poor (201-300), Very Poor (301-400), Severe (401-500).

The percentage of Forced Vital Capacity (FVC) expired in one second is called FEV₁% and is the most commonly used screening test for airway diseases. The 6 minute-walk test (6MWT) is a simple and inexpensive test for the objective evaluation of functional exercise capacity.

The aim of the present study was to observe the effect of short term ambient air pollution on functional exercise capacity and pulmonary function by using 6MWT and FEV₁% predicted.

Materials and Methods

This cross-sectional study was conducted in the Department of Physiology at ESIC Medical College, Faridabad. The study subjects comprised of 100 MBBS students both male and female. Informed consent was obtained from all the subjects and approval from Institutional Ethics Committee was taken.

Exclusion Criteria: Subjects with positive history of smoking, respiratory illness, musculoskeletal abnormality and heart disease were excluded from the study.

Lung Function: Lung function was measured in sitting posture using Digital Portable Spirometer (Cosmed Pony

FX model no. C09062-01-99), following American Thoracic Society (ATS) guidelines⁷. All tests were done between 10AM to 3PM and FEV₁% predicted was obtained.

Functional Exercise Capacity: The self-paced 6MWT assesses the submaximal level of functional exercise capacity. The test was performed between 10AM to 12 PM. The participants were instructed to take a light meal on the day of test and come wearing comfortable clothing and appropriate shoes. The 6MWT was performed indoors, along a long, flat, straight, enclosed corridor with a hard surface as per ATS guidelines.⁸ 6MWD was noted as an absolute value in meters.

Each subject underwent spirometry and 6MWT on two occasions, separated by at least one month interval. First time on a day when the AQI was good/satisfactory i.e. between 0-100 and second time when the AQI was poor/very poor/severe i.e. between 200-500. A change in the 6MWD by 50m and FEV₁% predicted by 15% was considered significant.

Statistical Analysis

Data was entered into MS-EXCEL 2007 and converted into a spreadsheet. Analysis was done using SPSS software version 17.0. The continuous variables (FEV₁% predicted, 6MWD) are presented in the form of mean and standard deviation. Paired t-test was applied to test the difference in both the variables on two different days when AQI was poor

and satisfactory. Independent t-test was applied to test the difference in mean in the two groups. Level of significance was set at 5%.

Results

The mean age of the participants was 19.07±0.68 yrs. Mean AQI on days when it was satisfactory was 86.47±8.17 and on days when it was poor was 288.76±44.46.

Fig.1 shows the difference in mean 6MWD and mean FEV₁% predicted on two occasions i.e. when the AQI was poor and when it was satisfactory. A change in the 6MWD by 50m and FEV₁% predicted by 15% was considered significant. Mean values of 6MWD and FEV₁% predicted in males and females on poor and satisfactory air quality days are given in Table 1. No significant gender differences have been found. Table 2 shows the mean 6MWD and FEV₁% predicted on poor and satisfactory air quality days for all the subjects.

Change in air quality resulted in a significant change in 6MWD in only 11% of the study subjects. There is no significant difference in the mean AQI for those with and without significant change in 6MWD (Table 3). Similarly only 2% of the subjects had significant change in FEV₁% predicted with a change in air quality. Significant difference was not found in the mean AQI for those with and without significant change in FEV₁% predicted (Table 3).

Table 1: Descriptive statistic of the study variables

AQI poor	N=100	Mean±2SD	p value
6MWD (m)	Male (67)	478.94±36.36	0.36
	Female (33)	486.19±39.53	
FEV ₁ % predicted	Male (67)	101.31±8.54	0.28
	Female (33)	103.24±7.97	
AQI satisfactory			
6MWD(m)	Male (67)	499.49±43.02	0.97
	Female (33)	499.18±38.44	
FEV ₁ % predicted	Male (67)	106.72±8.32	0.75
	Female (33)	106.09±10.93	

Table 2: Means of 6MWD and FEV₁% predicted on poor and satisfactory air quality days

	Mean	Std. Deviation
6MWD		
Mean 6MWD on Poor AQI days	481.33	37.39
Mean 6MWD on satisfactory AQI days	499.39	41.37
Mean of differences in 6MWD	18.05	24.01
FEV₁% predicted		
Mean FEV ₁ % predicted on poor AQI day	101.95	8.36
Mean FEV ₁ % predicted on Satisfactory AQI day	106.51	9.21
Mean of differences in FEV ₁ % predicted	-4.56	7.62

Table 3: Mean AQI of groups differing in significant / non-significant change in FEV₁% predicted and 6MWD

6MWD difference groups	No.	Mean AQI	Std. Deviation	p value
Significant (≥50m)	11	218.45	57.97	0.20
Non-significant (<50m)	89	200.29	42.35	
FEV₁% predicted difference groups				
Significant (≥15%)	2	180.00	14.14	0.48
Non-significant (<15%)	98	202.74	44.66	

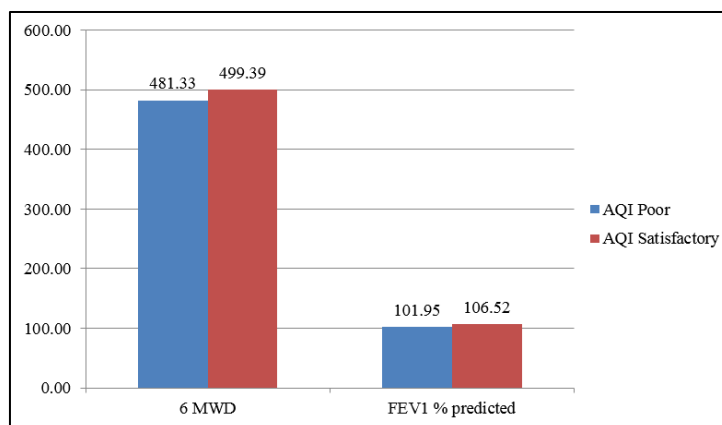


Fig. 1: Mean 6MWD and FEV₁% predicted on poor and satisfactory air quality days

Discussion

In the present study we observed the effect of short-term air pollution on lung function and functional exercise capacity. Throughout the period of study AQI was above 50, this shows that the air quality in Faridabad was never good. The mean AQI on satisfactory air quality days was 86.47 ± 8.167 and on bad air quality days was 288.67 ± 44.457 . Despite a significant difference in air quality on the days of study, no statistically significant negative impact of short term air pollution on FEV₁% predicted and 6MWD has been found. This is in contrast to most of the previous studies. A cohort study in the US reported acute adverse effects of PM 2.5, NO₂ and O₃ in the form of reduced FEV₁ and FVC.⁹ A Swiss cross sectional study also reported that acute exposure to total suspended particulate was significantly associated with decreased FEV₁ and FVC.¹⁰ A Brazil study at high air pollutant levels reported that increased moving averages of PM10 exposure were associated with lung function decline among school children.¹¹ However, our results are similar to the results of a study by Panis et al. They did not find an association between air pollution and FEV₁/FVC ratio. They also reported that the effects of short-term air pollution are smaller than the effects of long-term air pollution.¹² Possible reasons for our observations may be that the adverse effects of air pollution on lung function are cumulative. Our study subjects were young healthy adults, most of whom were residing in small towns of Haryana, Rajasthan and southern states of India prior to taking admission at Faridabad. Their duration of exposure to pollution was less than a year and that too in spells. Exposure to air pollutants over a long period directly irritates or corrodes lung epithelial cells or tissue, increases the permeability of alveolar and capillary walls, leading to pulmonary edema. Inhalation of NO₂ can also cause lung injury by inducing inflammation response and the imbalance of Th1/Th2 differentiation, and activating the JAK-STAT pathways.¹³

The 6MWT provides useful information of functional exercise capacity in patients of cardiorespiratory illness as well as in healthy individuals. The hypotheses we tested was that acute exposure to air pollution would result in a decrease in function exercise capacity. Vieira et al

conducted a randomized, double-blind and controlled FILTER-HF trial and studied the effect of diesel engine exhaust on functional exercise capacity. They reported that diesel engine exhaust adversely affects functional exercise capacity.¹⁴ However, in our study a change in air quality resulted in a significant change in 6MWD (>50m) in only 11% of the study subjects. It is possible that adverse effects of acute exposure to air pollution produces significant worsening of functional exercise capacity only in people at risk such as old people and people with cardiorespiratory illness.

Our results though not statistically significant still stress upon the need to develop air quality forecasts which can be used as a warning signal to sensitive individuals and formulate emergency measures to be taken under Graded Response Action Plan when the concentration of pollutants reach a certain level.

This information could also be used by various national, regional and local agencies to identify sources of air pollution and take effective measures to combat it.

Limitations

There are, however, several limitations to be mentioned as well. Since the study is an STS project, it had to be completed within a certain time frame, because of which the sample size of the study is small.

AQI is calculated by taking into consideration eight pollutants, some of which like NO₂ are traffic related pollutants that are known to exhibit a large spatial variation in concentration. Because the air quality monitoring station in Faridabad is a couple of kilometers away from the location where study was conducted and many participants travelled by two wheelers on the same morning, there is possibility of more exposure to pollutants and a variation in AQI.

Another limitation of this study is that we did not collect data on temperature or humidity, and control them as potential confounders, though the two factors did not vary dramatically during the study period. The results of this apparently healthy group of young adults cannot be extrapolated to other more vulnerable groups such as children, elderly or people with chronic conditions.

Conclusion

From this study it may be concluded that short term variation in particulate air pollution does not affect lung function and functional exercise capacity.

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Conflict of Interest: None.

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