

Association of Ambient Air Quality with Pulmonary Function of Youngster Footballers

Paulomi Das^{1ABCDG}; Pinaki Chatterjee^{2ABDEG}, PhD

Authors' Affiliation:

1. Department of Environmental Science, University of Kalyani, West Bengal, India
2. Office of the Secretary, Faculty Councils for Postgraduate Studies, University of Kalyani, West Bengal, India

Authors' Contribution

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* Corresponding Author;

Address: Office of the Secretary, Faculty Councils for Postgraduate Studies, University of Kalyani- 741235, West Bengal, India

E-mail: pnkchatterjee@yahoo.com

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Abstract

Purpose: Air pollution has remained a major health concern in Kolkata. The present study was carried out to analyze the association between the levels of air pollutants and pulmonary function of youngster footballers living in two different air pollutant zones of Kolkata, West Bengal.

Methods: Air pollution data of the two ambient air quality-monitoring stations located at Rabindrabharati and Victoria Memorial was collected for the period from January 2012 to March 2012. Study was conducted on two hundred and twenty boys of the age range 14-16 years living within 3km radius of the two monitoring stations. Sample consisted of 60 footballers (30 from Rabindrabharati and 30 from Victoria Memorial) and 160 sedentary boys (80 from Rabindrabharati and 80 from Victoria Memorial). They were investigated for their spirometric lung functions by the method and technique recommended by American Thoracic Society. Results were expressed as mean \pm SD and independent samples T test was conducted to compare between two groups.

Results: Results revealed that particulate matter (PM₁₀), oxides of sulfur (SO₂) concentrations were significantly higher in Rabindrabharati zone, whereas no significant differences were noted in oxides of nitrogen (NO₂) and carbon monoxide (CO) concentrations though values were higher at Rabindrabharati than Victoria Memorial. Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV₁), forced mid expiratory flow (FEF₂₅₋₇₅%), maximum voluntary ventilation (MVV) were significantly lower both in footballers ($P < 0.05$) and sedentary boys ($P < 0.01$) of Rabindrabharati zone.

Conclusion: Exposure to high air pollutant concentration might be associated with reduced pulmonary function in both sedentary and trained boys in spite of the fact that regular participation in training program may improve pulmonary function.

Key Words: Air Pollution; Pulmonary Function Test; Forced Vital Capacity; Footballers

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INTRODUCTION

Nowadays, people cannot keep away from the global problem of air pollution caused by automobile exhausts as long as they live in urban areas. Exposure to particulate air pollution has been associated with increase in cardiovascular and respiratory disease and mortality in many countries [1,2] including India [3,4]. The air pollution level of Kolkata,

the capital of West Bengal is escalating day by day and one of the significant sources of air pollution in Kolkata is automobiles (Department of Environment, Government of West Bengal and West Bengal Pollution Control Board, 2002). 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 sulfur (SO₂), oxides of nitrogen (NO₂), and carbon monoxide

(CO), which creates adverse health effects on the exposed population.

It is a well known fact that exercises in the form of sports, aerobics or workouts, if performed regularly have a favorable effect on various systems of the body. Previous studies showed that sportspersons have higher values of lung volumes in comparison to their control counterparts who are not engaged in regular physical exercise [5,6]. Lung function is an important measure of respiratory health and a predictor of cardiorespiratory morbidity and mortality [7]. Lung function tests provide qualitative and quantitative evaluation of pulmonary function as well as establish the function of lung capacity and 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 [8]. Several studies have shown the adverse effects of air pollution on pulmonary ventilation [9,10]. The relationship between pollution level (PM10) and degree of impairment of pulmonary ventilation was also noted [11]. According to Linares *et al*, [12] spirometric abnormalities were more frequent in the school children closer to the most polluted area. Many studies [13,14] have demonstrated the influence of air pollution on children's pulmonary function, and it has been stated that in areas of high concentration of nitric oxide, the values of children's pulmonary function parameters are low and their growth is comparatively delayed [14].

It is an unquestionable fact that regular physical activity is beneficial to health and longevity. People should not be deterred from regular exercise as it is of known benefit, but during exercising they should avoid areas with high pollutant concentrations [15]. Carlisle and Sharp [16] reported that personal exposure to PM10 of people exercising at the roadside in the city was higher than that of the sedentary person and those exercising in rural locations. So, this study examines the differences between levels of selected pulmonary function parameters [Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), forced mid expiratory flow (FEF25-75%), maximum voluntary ventilation (MVV)] of 14-16 years old footballers from two regions of Kolkata with differing degrees of air pollution. In addition an attempt also has been made to evaluate the effect of air pollution on

FVC, FEV₁, FEF_{25-75%}, MVV of sedentary boys of the same age range residing those zones of Kolkata and to elucidate whether the degree of effect of air pollution may differ between footballers and sedentary boys i.e. control group.

METHODS AND SUBJECTS

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, 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), SO₂, NO₂ and CO.

Subjects:

According to Krejcie and Morgan [17], the sample size was estimated. Study was conducted on two hundred twenty boys of the age range 14-16 years. Among them 30 footballers and 80 untrained boys were from Rabindrabharati (North Kolkata). The remaining 30 footballers and 80 untrained boys were from another zone, Victoria Memorial (Central Kolkata). Boys selected for the study were living within a 3 km radius of the 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 the boys were from the same economic status following the categorization as set up by the West Bengal Housing Board [18] and they were from same nutritional status [19]. The footballers in the study were trained boys as they had minimum three years training and they were undergoing regular practice and training. But the untrained boys did neither regular practice and training nor any regular physical activity program. 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.

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^[20] and Meltzer's equation^[21] respectively.

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^[22]. The spirometric measures consisted of FVC, FEV₁, FEF_{25-75%}, MVV. The terminology of the ventilatory function tests is in accordance with the recommendations of the American Thoracic Society^[22]. 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^[22]. Measurement and calculations of spirometric results were made according to the techniques recommended by Kory et al^[23] and

Intermountain Thoracic Society^[24]. 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 a Palmer respiratory hand pump.

Statistical Analysis:

All the values are expressed as mean \pm standard Deviations (SD). SPSS version 20 was used for analysis. Independent samples t test was adopted for statistical analysis of the data.

RESULTS

The ambient air quality data (Mean \pm SD) as reported by WBPCB in the two areas of Kolkata along with National Ambient Air Quality Standard are shown in table 1. Values of PM10 of both regions were much more than the national ambient air quality standards, while SO₂ was within the standards. On the other hand, NO₂ of Rabindrabharati showed higher values than standard but it was lower in the other zone. Comparison of the two ambient air quality data revealed that PM10 and SO₂ were significantly higher ($P<0.01$) in Rabindrabharati than Victoria Memorial zone whereas no significant difference was obtained in NO₂ and CO, although values were higher in Rabindrabharati area.

Mean (SD) values of anthropometric parameters and pulmonary function test parameters along with significance level between footballers and untrained boys of two zones are given in table 2. Difference of anthropometric parameters and pulmonary function test

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	P. Value*
Particulate matter PM10 ($\mu\text{g}/\text{m}^3$)	100	184.03 (53.76)	125.27 (63.59)	<0.01
SO ₂ ($\mu\text{g}/\text{m}^3$)	80	28.34 (16.27)	7.15 (4.20)	<0.01
NO ₂ ($\mu\text{g}/\text{m}^3$)	80	81.60 (49.16)	75.02 (43.15)	NS
CO (mg/m^3)	04	1.59 (1.76)	1.43 (0.78)	NS

* t-test; SO₂: Oxides of sulfur, NO₂: Oxides of nitrogen; CO: Carbon monoxide; NS: Not Significant

Table 2: Level of significance of difference in anthropometric, physiological and pulmonary function test parameters between footballers and untrained boys of two regions

Parameters	Rabindrabharati			Victoria Memorial		
	Footballers (n=30)	Untrained boys (n=80)	P. Value	Footballers (n=30)	Untrained boys (n=80)	P. Value
	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
Height (cm)	157.88 (4.46)	159.09 (8.65)	NS	157.96 (6.46)	160.72 (7.01)	NS
Weight (kg)	43.55 (4.11)	49.87 (8.41)	<0.01	41.45 (5.91)	48.82 (7.69)	<0.01
BSA (m ²)	1.40 (0.07)	1.49 (0.15)	<0.01	1.37 (0.11)	1.49 (0.12)	<0.01
BMI (kg/m ²)	17.48 (1.54)	19.64 (2.63)	<0.01	16.58 (1.96)	18.93 (2.97)	<0.01
FVC (l)	3.21 (0.52)	2.74 (0.56)	<0.01	3.48 (0.45)	2.96 (0.53)	<0.01
FEV ₁ (l)	2.87 (0.51)	2.49 (0.28)	<0.01	3.17 (0.62)	2.64 (0.21)	<0.01
FEF _{25-75%} (l/s)	4.52 (0.74)	4.10 (0.77)	<0.01	4.96 (0.85)	4.42 (0.69)	<0.01
MVV (l/min)	112.52 (19.25)	90.08 (23.69)	<0.01	123.64(20.79)	99.46 (21.20)	<0.01

BSA: Body surface area; BMI: Body mass index; FVC: Forced vital capacity; FEV₁: Forced expiratory volume in 1 second; FEF_{25-75%}: Forced mid expiratory flow; MVV: maximum voluntary ventilation; NS: Not Significant

parameters of the footballers and sedentary boys residing in the two zones of Kolkata are shown in table 3 and table 4 respectively. From table 2, it was clear that weight, BSA and BMI were significantly higher in untrained boys of both regions than footballers (trained boys) though no significant difference was observed in their height. On the other hand all pulmonary function test parameters were significantly higher in footballers than their sedentary counterparts in both regions. Tables 3 and 4 showed no statistical difference between the groups in these anthropometric parameters. But FVC, FEV₁, FEF_{25-75%}, MVV were significantly higher in both footballers ($P<0.05$) and sedentary boys ($P<0.01$) of Victoria Memorial zone compared to Rabindrabharati zone.

DISCUSSION

It is a well known fact that Pulmonary Function values are influenced by race, age, sex, height, weight [25,26,27], physical activity patterns [28,29] and other unknown variables having a wide range of normal values [30]. Lung function parameters in an apparently healthy population may be influenced by socioeconomic and nutritional status [31,32] as well as atmospheric pollution levels [33].

It was observed that the mean FVC, FEV₁, FEF_{25-75%}, MVV values of sedentary boys of the present study were fairly comparable to the data obtained for male subjects in other studies conducted on normal school children in North India [27].

Table 3: Level of significance of difference in anthropometric, physiological and pulmonary function test parameters of footballer groups

Parameters	Rabindrabharati (n=30)	Victoria Memorial (n=30)	P. value
Height (cm)	157.88 (4.46)	157.96 (6.46)	NS
Weight (kg)	43.55 (4.11)	41.45 (5.91)	NS
Body surface area (m ²)	1.40 (0.07)	1.37 (0.11)	NS
Body mass index (kg/m ²)	17.48 (1.54)	16.58 (1.96)	NS
Forced vital capacity (l)	3.21 (0.52)	3.48 (0.45)	<0.05
Forced expiratory volume in 1 second (l)	2.87 (0.51)	3.17 (0.62)	<0.05
Forced mid expiratory flow (l/s)	4.52 (0.74)	4.96 (0.85)	<0.05
Maximum voluntary ventilation (l/min)	112.52 (19.25)	123.64 (20.79)	<0.05

NS= Not Significant

Table 4: Level of significance of difference in anthropometric, physiological and pulmonary function test parameters of sedentary groups

Parameters	Rabindrabharati (n=80)	Victoria Memorial (n=80)	P. value
Height (cm)	159.09 (8.65)	160.72 (7.01)	NS
Weight (kg)	49.87 (8.41)	48.82 (7.69)	NS
Body surface area (m ²)	1.49 (0.15)	1.49 (0.12)	NS
Body mass index (kg/m ²)	19.64 (2.63)	18.93 (2.97)	NS
Forced vital capacity (l)	2.74 (0.56)	2.96 (0.53)	<0.01
Forced expiratory volume in 1 second (l)	2.49 (0.28)	2.64 (0.21)	<0.01
Forced mid expiratory flow (l/s)	4.10 (0.77)	4.42 (0.69)	<0.01
Maximum voluntary ventilation (l/min)	90.08 (23.69)	99.45 (21.20)	<0.01

NS: Not Significant

Involvement in sports is one of the common characters of human beings and it starts to develop from the very beginning of childhood. But with the development of age, some people participate in recreational or amateur sports whereas very few individuals contribute themselves to become true sports persons by regular practice and training which allows them to improve their psychological adjustments towards their goal. However, the basic physiological parameters are cardiovascular and respiratory adaptation, haematological changes, development of autonomic reflexes, maintenance of rhythmic endocrine orchestra, proper body build up etc. Lung function parameters tend to have a relationship with regular exercise and non exercise [34, 35]. Our study revealed that all lung function parameters were higher in footballers than their sedentary counterparts in both regions which were similar to the reports from other workers [36, 37] who indicated a significantly higher lung function in athletes compared with non athletes. According to Sable et al, [38] there were significant increases in FVC, FEV₁ and MVV in runners compared to non runners, probably due to training there was improvement in the lung functions and strengthening of respiratory muscles.

Literature suggests the undesirable effects of continuing exposure to ambient air pollution on lung function [7] and impacts of outdoor air pollution both from acute and long term disclosure, contribution to risk of respiratory symptoms, reduced lung function, increased heart disease [39], as well as increasing mortality [40]. Goyal and Khaliq [41] reported a

relationship between SO₂ exposure and daily mortality, morbidity and a reduction of FEV₁ in urban areas. Peters et al, [13] revealed that PM₁₀, PM_{2.5}, and NO₂ were each significantly associated with lower FVC, FEV₁, and maximal midexpiratory flow (MMEF) in Southern California public school children. A study in south-east England exposed statistically significant adverse effects of airborne respirable particulate matter, measured as PM₁₀, on lung function in children [42]. Another study by Chang et al, [43] concluded that the short-term exposure to O₃ and PM₁₀ was associated with reducing FVC and FEV₁ in adolescent school students in a mass screening program in Taipei city, Taiwan.

It is an unquestionable fact that regular physical activity is beneficial to health and longevity. Accordingly it is common practice for physicians and other health care professionals to encourage exercise. However, people exercising in air polluted regions may be unwittingly at risk. Fisher and Cerny [44] also reported that pulmonary diffusion capacity has been shown to increase with exercise, it may therefore be postulated that the diffusion of pollutant gases increases with exercise. So athletes are especially at risk of inhaling pollutants. Das et al, [45] also showed that one of the physical fitness components of footballers in less pollutant zones was significantly higher than footballers from highly polluted zones in West Bengal, India. Study conducted by Das et al, [46] also showed the impact of air pollutant on physical fitness components including VO_{2max} of sports persons in West Bengal, India. Another study by Das et al, [47]

also concluded that environmental air pollutants have adverse effect on physical fitness components of both sprinter and untrained boys. 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 ^[41].

The present study also disclosed the fact of adverse effect on lung function on footballers as well as sedentary boys. Air pollutant concentration was observed to be higher in Rabindrabharati zone than Victoria Memorial zone of Kolkata and some of the pollutant showed significantly higher values in Rabindrabharati zone. In our study the sedentary boys from the two regions were from the same socio-economic status. One group came from Victoria Memorial zone where the pollutant level was low and other was from Rabindrabharati zone where the air pollutant level was high. Results confirmed that there were no significant differences in their height, weight, BSA and BMI also. In spite of that, FVC, FEV₁, FEF_{25-75%}, MVV was lower ($p < 0.01$) for sedentary boys from Rabindrabharati. Similar case has been found in footballer groups where in spite of belonging to same socio-economic status, FVC, FEV₁, FEF_{25-75%}, MVV was higher ($p < 0.05$) for Victoria Memorial than Rabindrabharati zone though no significant difference was observed in anthropometric parameters. Hence, it appears that it was only environmental factors which might be the major decisive factor for the difference in pulmonary function. Chattopadhyay et al, ^[48] 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 to such environment may develop lung functional impairments.

Association of atmospheric pollutants with many types of health problems of many body systems was revealed by different studies. Some studies have stated the increases in respiratory and cardiovascular troubles at outdoor pollutant levels well beneath standards set by such agencies as the US EPA (United States Environmental Protection Agency) and WHO ^[49]. Adverse effects on respiratory health are not limited to high concentrations of air pollutants, but have also been observed at relatively low concentrations ^[50].

Harmful 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 ^[51]. 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 ^[52]. Both controlled human studies and observational studies suggest that air pollution adversely affects athletic performance during both training and competition and the air pollution dosage during exercise is much higher than during rest because of a higher ventilatory rate and both nasal and oral breathing in the former case ^[53]. So, in our study the lower pulmonary function i.e. decreased values of FVC, FEV₁, FEF_{25-75%}, MVV in both footballers and sedentary boys of Rabindrabharati zone might be due to the impact of higher air pollutants which warrants further investigation. But no definite clear vision can be obtained regarding the degree of effect of air pollution on trained and sedentary subjects. However, comparing the results of two zones, it is observed that the value of lung function parameters of the trained subjects differs at 0.05 level where as for sedentary subjects the level of difference is 0.01. Although, from this observation no conclusive decision can be made, there is indication that regular exercise and training may contribute to combat adverse effect of pollution on lung function status.

CONCLUSION

From the present study it was revealed that environmental air pollutants might have an adverse effect on pulmonary function irrespective of whether the boys were undergoing regular physical training or not. Further investigation is required regarding whether the degree of effect of air pollution on trained and sedentary subjects may vary.

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Conflict of interests: None

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