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ORIGINAL RESEARCH

Evaluation of Respiratory Function of Residents around the Thermal Power Plant in Central India: A Comparative Cross Sectional Study

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ABSTRACT

Background: The communities living close to the chimneys of thermal power plants are exposed to the toxic effects of sulfur dioxide, which causes respiratory system symptoms, worsen existing lung diseases, and causes decline in respiratory function. In this survey ,spirometry is used to detect aberrant lung function in people who are exposed to injurious agent. **Objective:** To evaluate the respiratory functions of the residents around the thermal power plant in central India. **Material and Methods:** This comparative cross-sectional study was conducted in the Department of Respiratory Medicine of a tertiary care hospital and medical college situated in the central India. In this study, 102 individuals enrolled in case group and 102 individuals enrolled in control group. **Results:** Significantly greater proportion of individuals in study group had chest tightness (p-value = 0.001) and repeated cough > 1 year (p-value = 0.007). However, the groups did not differ significantly in terms of productive cough (p-value = 0.104). For chest tightness, significantly greater proportion of individuals in study group than control group were aged > 65 years (p-value = 0.027). For repeated cough >1 year, significantly greater proportion of individuals in study group than control group were aged > 65 years (p- value = 0.041). Overall, the mean FEV1 (p-value = 0.001), FVC (p-value = 0.019), and FEF25-75% (p-value < 0.0001) were significantly higher among individuals in control group than study group. **Conclusion:** Spirometric findings are affected by living within the vicinity of a coal-fired thermal power plant. Particularly, all spirometric parameters are affected, suggesting obstructive and restrictive diseases.

Keywords: Repiratory Function, Resident, Thermal Power Plant.

INTRODUCTION

Thermal power plants are the principal source of atmospheric sulphur, with sulphur dioxide being produced mainly through coal combustion.(1) The most significant source of nitrogen oxide is the burning of fossil fuels.(1) Fly ash from coal combustion pollutes not only the soil, but also ground and surface water and can pose a threat to human health in the form of inhalable particles smaller than 10 mm, which can lodge in the respiratory system.(1) The harm caused by such particles depends on the chemical structure of the particle, the condition of the lungs, and individual differences in lung function.(2)

There is epidemiological evidence to suggest that air pollution impairs respiratory function, notwithstanding lung development and age.(3) It has been reported that respiratory illnesses

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and insufficiency of lung functions are more frequently seen among children living in environments where air pollution is a problem.[(1)]

In epidemiological surveys, spirometry is used to detect aberrant lung function in people who are exposed to injurious agents.[(4)] Several studies have used spirometry to evaluate mechanical lung function.[(5)] Spirometry is regarded as the best method for evaluating mechanical lung function as it is portable, practical, and repeatable.[(6)]

Insufficient breathing, asthma attacks, and then emergency room visits and hospital admissions follow functional decline in the lungs.[(7)] Nitrogen oxides and sulfur dioxide released from thermal power plants are considered to be the most polluting air contaminants. The amount of these 2 contaminants released from power plants with technology older than 30 years is 10 times more than that of modern power plants.[(1)] Exposure to ash causes a decrease in vital capacity and total lung capacity, but it is not easy to evaluate these changes.[(8)]

The communities living close to the chimneys of thermal power plants are exposed to the toxic effects of sulfur dioxide, which causes respiratory system symptoms, worsens existing lung diseases, and causes a decline in respiratory function.[(9)] Respiratory system symptoms and deteriorated lung functions have been increasingly observed among children living in regions with high air pollution.[(4)] An increase in SO2 concentration by 1 unit causes a 35.6 mL and 131.4 mL decrease in FEV1 and FVC, respectively.(10) A study by Karavuş et al. reported that, as a group, residents living near thermal power plant had lower FEV1 values compared with controls. Also, non-smokers in their study group had lower FEV1 and FVC values compared with non-smoker controls.[(11)]

India has various thermal power plants. However, respiratory function of residents around the thermal power plant has not been evaluated sufficiently, especially among the residents of central India. Thus, the present study evaluated the respiratory functions of the residents around the thermal power plant in central India.

MATERIAL & METHODS

This comparative cross-sectional study was conducted in the Department of Respiratory Medicine of a tertiary care hospital and medical college situated in the central India. All adult individuals living around thermal power plant (within 2 km radius; study group) and individuals living away from thermal power plant (20 km away; control group). The study was conducted from October 2020 to September 2022. Approval from the Institutional Ethics Committee (IEC) was sought. Informed written consent in Subject's vernacular language was taken before enrolment for study.

Inclusion Criteria

Study Group

1. Individuals aged 18 years or above,
2. Individuals of either gender,
3. Individuals living within 2 km radius of thermal power plant, and
4. Individuals with a minimum duration of stay in area more than 1 year

Control Group

1. Individuals aged 18 years or above,
2. Individuals of either gender,
3. Individuals living 20 km away from of thermal power plant, and
4. Individuals with a minimum duration of stay in area more than 1 year.

Exclusion Criteria

Study and Control Group

1. Individuals aged less than 18 years,
2. Individuals with a duration of stay is less than 1 year,

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3. Individuals unable to perform spirometry test,
4. Individuals not willing to participate for study

At the time of enrolment, following parameters were noted in all the patients.

Demographic Characteristics

Included age, gender, education, occupation, and smoking.

Clinical Characteristics

Included pulmonary symptoms (chest rightness, repeated cough for > 1 year, and productive cough > 1 year), and spirometric parameters (FEV1, FVC, FEV1/FVC, and FEF25-75%).

Study Procedure

A total of 106 individuals in study group and 105 individuals in control group were initially screened for the study and were explained the study procedure in their native language. In study group, 2 individuals did not give consent, and 2 could not perform spirometry. Thus, remaining 102 individuals were enrolled in the study. In control group, 2 individuals did not give consent, and thus, remaining 102 individuals were enrolled in the study.

Following enrollment, a thorough history was taken and demographic parameters, including age, gender, education, occupation, and smoking were recorded. Following this, patients were assessed for pulmonary symptoms (chest rightness, repeated cough for > 1 year, and productive cough > 1 year). Subsequently, patients were subjected to spirometry and parameters (FEV1, FVC, FEV1/FVC, and FEF25-75%) were evaluated. All the findings were recorded in a specifically designed case report form.

Statistical Analyses

Data was collected and graphics were designed by Microsoft Office Excel 2019. The data was analyzed with SPSS (IBM, Armonk, NY, USA) version 23.0 for windows. The categorical and continuous variables are represented as frequency (percentage) and mean (standard deviation, SD), respectively

RESULTS

In both the groups, majority of the individuals were aged < 40 years (study group = 42.16%; control group = 44.12%). On analysis by Chi-square test, the groups did not differ significantly in any of the age groups (all p-values > 0.05). Moreover, analysis by independent sample t-test, the groups did not differ significantly in terms of mean age (p-value = 0.859).

In both the groups, majority of the individuals were males (study group = 54.91%; control group = 56.86%). On analysis by Chi-square test, the groups did not differ significantly in terms of gender (p-value = 0.778).

In both the groups, majority of the individuals had secondary education (study group = 43.14%; control group = 42.16%). On analysis by Chi-square test, the groups did not differ significantly in terms of education (all p-values > 0.05).

In both the groups, majority of the individuals were housewife (study group = 33.33%; control group = 30.39%). On analysis by Chi-square test, the groups did not differ significantly in terms of occupation (all p-values > 0.05).

In both the groups, majority of the individuals were non-smokers (study group = 63.73%; control group = 60.78%). On analysis by Chi-square test, the groups did not differ significantly in terms of smoking status (p-value = 0.665).

On analysis by Chi-square test, significantly greater proportion of individuals among study group had chest tightness (p-value = 0.001) and repeated cough > 1 year (p-value = 0.007). However, the groups did not differ significantly in terms of productive cough (p-value = 0.104).

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Table 1: Comparison of pulmonary complaints

Complaints	Study group (n=102)	Control group (n=102)	p-value
CT	47 (46.08%)	25 (24.51%)	0.001
RC >1 year	35 (34.31%)	18 (17.65%)	0.007
PC	18 (17.65%)	10 (9.80%)	0.104

CT: Chest tightness; RC: Repeated cough; PC: Productive cough

On analysis by Chi-square test, significantly greater proportion of individuals aged > 65 years among study group had chest tightness (p-value = 0.027). However, the groups did not differ significantly in the age group of < 45 years (p-value = 0.134) and 45 – 65 years (p-value = 0.264).

Table 2: Comparison of chest tightness according to age

Chest tightness	Study group (n=47)	Control group (n=25)	p-value
< 45 years	5 (10.65%)	6 (24.00%)	0.134
45 – 65 years	18 (38.29%)	13 (52.00%)	0.264
> 65 years	24 (51.06%)	6 (24.00%)	0.027

On analysis by Chi-square test, significantly greater proportion of individuals aged > 65 years among study group had repeated cough >1 year (p-value = 0.041). However, the groups did not differ significantly in the age group of < 45 years (p-value = 0.234) and 45 – 65 years (p-value = 0.220).

Table 3: Comparison of repeated cough >1 year according to age

Repeatedcough >1 year	Study group (n=35)	Control group (n=18)	p-value
< 45 years	5 (14.28%)	5 (27.78%)	0.234
45 – 65 years	8 (22.86%)	7 (38.89%)	0.220
> 65 years	22 (62.86%)	6 (33.33%)	0.041

On analysis by Chi-square test, the groups did not differ significantly in the age group of < 45 years (p-value = 0.418), 45 – 65 years (p-value = 0.724), and > 65 years (p-value = 0.778).

Table 4: Comparison of productive cough according to age

Productive cough	Study group (n=18)	Control group (n=10)	p-value
< 45 years	4 (22.22%)	1 (10%)	0.418
45 – 65 years	6 (33.33%)	4 (40%)	0.724
> 65 years	8 (44.44%)	5 (50%)	0.778

On analysis by independent sample t-test, the mean FEV1 (p-value = 0.001), FVC (p-value = 0.019), and FEF25-75% (p-value < 0.0001) were significantly higher among individuals in control group than study group. However, the groups did not differ significantly in terms of mean FEV1/FVC (p-value = 0.586).

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Table 5: Comparison of PFT parameters: Total population

Parameters	Study group (n=102)	Control group (n=102)	p-value
FEV1	92.41 ± 10.07	97.44 ± 10.57	0.001
FVC	96.92 ± 11.49	100.92 ± 12.73	0.019
FEV1/FVC	82.47 ± 10.12	81.73 ± 9.37	0.586
FEF25-75%	69.25 ± 9.99	74.46 ± 10.73	< 0.0001

On analysis by independent sample t-test, the mean FEV1 (p-value < 0.0001), FVC (p-value = 0.005), and FEV1/FVC (p-value < 0.0001) were significantly higher among individuals in control group than study group. However, the mean FEF25-75% (p-value = 0.028) was significantly higher among individuals in study group than control group.

Table 6: Comparison of PFT parameters: Smokers

Parameters	Study group (n=37)	Control group (n=40)	p-value
FEV1	80.59 ± 5.22	89.62 ± 10.03	< 0.0001
FVC	83.71 ± 5.19	89.27 ± 10.42	0.005
FEV1/FVC	70.45 ± 5.15	79.23 ± 10.64	< 0.0001
FEF25-75%	74.52 ± 10.03	69.28 ± 10.38	0.028

On analysis by independent sample t-test, the mean FEV1 (p-value = 0.002), FVC (p-value = 0.001), and FEF25-75% (p-value < 0.0001) were significantly higher among individuals in control group than study group. However, the mean FEV1/FVC (p-value < 0.0001) was significantly higher among individuals in study group than control group.

DISCUSSION

In the present study, majority of the individuals in both the groups were aged < 40 years (study group = 42.16%; control group = 44.12%), males (study group = 54.91%; control group = 56.86%), had secondary education (study group = 43.14%; control group = 42.16%), were housewife (study group = 33.33%; control group = 30.39%), and non-smokers (study group = 63.73%; control group = 60.78%).

Moreover, the groups did not differ significantly in any of the age groups (all p-values > 0.05), mean age (p-value = 0.859), gender (p-value = 0.778). Education (all p- values > 0.05), occupation (all p-values > 0.05), and smoking status (p-value = 0.665). Thus, both the groups were homogenous in terms of demographic profile. In their study, **Pala et al.** found that the study and control groups did not differ significantly in age groups, gender, and smoking.(1) However, the groups differed significantly in terms of education and occupation.(12)

The communities living close to the chimneys of thermal power plants are exposed to the toxic effects of sulfur dioxide, which causes respiratory system symptoms, worsens existing lung diseases, and causes a decline in respiratory function.

Nitrogen oxides also affected the respiratory systems of people nearby negatively.(12)

An increase in SO2 concentration by 1 unit causes a 35.6 mL and 131.4 mL decrease in FEV1 and FVC, respectively.(10) In their study, **Goren et al.** evaluated the school children living within 19 km of a coal-fired power plant, and observed that respiratory symptoms of cough without sputum and cough accompanied by sputum were increase 3 and 6 years after the power plant began to operate.(13)

In the present study, significantly greater proportion of individuals among study group had chest tightness (p-value = 0.001) and repeated cough > 1 year (p-value = 0.007). However, the groups did not differ significantly in terms of productive cough (p-value = 0.104). In agreement with the present study, **Karavuş et al.** observed that significantly greater

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proportion of individuals in study group than control group compliant of chest tightness (46.2% vs 28%; p-value = 0.001) and repeated coughing attacks present for more than one year (29.2% vs 20.4%; p-value = 0.024). However, the groups did not differ significantly in terms of productive coughing present for more than one year (13.3% vs 8.4%; p-value = 0.0885).(11)

The residents of the villages around the power plant are found to have a statistically significant effect on parameters of spirometric measurements of FEV1 and FEF25- 75%. Some studies indicate that the exposure to environmental air pollution has a dose-dependent effect on pulmonary functions.(15) In other words, as years of life pass in a polluted area, we can expect the pulmonary functions to be lowered. It also reported that pulmonary functions are affected with increasing age; however, since the spirometry used in this study was adjusted according to individual's age, it can be concluded that this statistical difference is due to years of life exposed to the pollutants.(14)

In this study, **Roger et al.** observed that increased concentrations of PM10 and SO2 in the air resulted in a decrease in the percentages of FVC and FEV1, respectively.(15) In another study by **Goren et al.**, the annual increase in FVC and FEV1 was lowest in the four subgroups from the community expected to be the most polluted, but highest in the community expected to be moderately polluted, implying that not only FEV1 but also FVC is affected by the increase of pollutants in the air.(13)

In the present study, overall, the mean FEV1 (p-value = 0.001), FVC (p-value = 0.019), and FEF25-75% (p-value < 0.0001) were significantly higher among individuals in control group than study group. However, the groups did not differ significantly in terms of mean FEV1/FVC (p-value = 0.586). Among smokers, the mean FEV1 (p-value < 0.0001), FVC (p-value = 0.005), and FEV1/FVC (p-value < 0.0001) were significantly higher among individuals in control group than study group. However, the mean FEF25-75% (p-value = 0.028) was significantly higher among individuals in study group than control group. Among non-smokers, the mean FEV1 (p-value = 0.002), FVC (p-value = 0.001), and FEF25-75% (p-value < 0.0001) were significantly higher among individuals in control group than study group. However, the mean FEV1/FVC (p-value < 0.0001) was significantly higher amongindividuals in study group than control group.

In the present study, significant difference was detected between the spirometric parameters of the smokers and non-smokers of the two groups. This could indicate that, for non- smokers living in the area of the power plant, spirometric findings can change to indicate both obstructive and restrictive ventilatory defects. The findings of other studies have revealed similar results, indicating that the effects of air pollution is reflected more on spirometry if the individuals were smokers.(16)

In consensus with the present study, **Pala et al.** demonstrated that, for overall population, FEV1 (p-value < 0.001) and FVC (p-value < 0.001) were significantly higher among the control group. While, FEV1/FVC (p-value < 0.001) was significantly higher among the study group. Among smokers, FEV1 (p-value = 0.017) and FVC (p-value < 0.001) were significantly higher among the control group. While, FEF25-75% (p-value = 0.003) and FEV1/FVC (p-value < 0.001) were significantly higher among the study group. Among non-smokers, FEV1 (p-value < 0.001) and FVC (p-value < 0.001) were significantly higher among the control group. While, and FEV1/FVC (p-value < 0.001) were significantly higher among the study group.(12)

CONCLUSION

Spirometric findings are affected by living within the vicinity of a coal-fired thermal power plant. Particularly, all spirometric parameters are affected, suggesting obstructive and restrictive diseases. Proper protective measures should be taken by the residents and regular

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check-ups should be done to know any pulmonary impairment. Moreover, follow-up studies are recommended in the area to compare the morbidity and mortality rates due to the pulmonary diseases.

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