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Occupational impact of increased dust duration on pulmonary capacities of workers

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ABSTRACT

Aim: Occupational lung diseases are usually caused due to chronic exposure to dust or irritating toxic substance. In India, morbidity due to occupational lung diseases has been reported to be high. Therefore, this study was carried out to determine the impact of long-term occupational barytes dust exposure on pulmonary capacities of workers.

Methods: The present cross-sectional study was conducted on 332 participants within the age group of 22–60 years in 2013. The Data regarding demographic, behavioural and occupational characteristics were collected by pre-designed questionnaire. Spirometry is an important tool for the detection of pulmonary diseases in its earlier stages. Pulmonary functions were assessed by Schiller spirometry in 240 surface mine exposed workers who engaged in direct mining activities and 92 age matched healthy administrative staff workers as non exposed workers.

Results: It was observed that 15.8% of exposed workers had restrictive pulmonary impairment as compared to 6.5% among nonexposed workers, and the difference was statistically significant ($p < 0.05$). Furthermore, the difference between the mean values of forced vital capacity and forced expiratory volume in one second (FEV1) among the studied groups was statistically significant ($p < 0.01$). It was also observed that as the duration of exposure increases, the pulmonary function decreases. This decrease in pulmonary function was statistically significant ($p < 0.001$). Pearson's correlation r values indicated a poor correlation between the duration of dust exposure and pulmonary function of studied workers.

Conclusion: The study emphasizes the need for regular monitoring of the dust levels and awareness about the importance of personal protective devices among the workers to mitigate respiratory morbidity.

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Introduction

Occupational lung diseases are usually caused due to chronic exposure to dust or irritating toxic substance. Certain occupations are associated with an increased risk of developing occupational lung diseases. These occupations include mining, construction, industry workers overexposed to chemicals, and farmers who are exposed to a variety of dust. Among these, miners are the most vulnerable population as they are exposed to mineral dust throughout their working life. Occupational lung diseases are often incurable, but they are always preventable. In India, morbidity due to occupational lung diseases among mine workers has been reported to be high [1–4].

Barytes rocks are richly available in YSR kadapa district as a barium sulphate and are transported to different parts of the country [5]. Barytes is widely used in several industries like paints, paper, ceramic, glass and rubber manufacturing industry, production of electronics component and as drilling mud in oil and gas exploration [6]. During mining of the crude barytes ore workers are exposed to dust which may cause baritosis [7]. In a small factory, Doig reported 9 cases of baritosis where barytes was crushed, grated and milled [8]. Arrigoni first described the baritosis among barytes miners in Italy [9-10]; it results from the inhalation of respirable particles of barium sulphate causing dense radiologic opacities but no functional impairment.

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Spirometry has been widely used for the determination of the functional capacity of the lung in workers exposed to a dusty environment. It gives important information about the lung function parameters, such as forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and the percentage ratio of FEV1/FVC%, and is also used for the evaluation of changes that have been occurred. Periodic spirometry in workers can detect pulmonary diseases in its earlier stages when corrective measures are more likely to be beneficial. The importance of spirometry for the determination of early respiratory function changes associated with occupational dust exposure has validated by numerous epidemiological studies [11].

For mitigating occupational lung diseases, the implementation of preventive strategies such as the use of personal protective devices among the workers is helpful. Equally, the detection of lung diseases at an early stage and regular follow-up is also important to control and prevent further progression of the disease. This is probably the first study undertaken to determine the lung function impairment among the baryte miners and also to correlate with the duration of work exposure relationship among workers.

Materials and Methods

Study design and procedure

The present study was cross-sectional in design, and it was conducted among 357 male participants belonging to the age group of 22–60 years with the same sociodemographic status in 2013. A total of 332 participants were enrolled for data analysis. The information of all participants regarding their height weight, smoking, occupation, illness history and use of personal protective equipment (PPE) was recorded on pre-designed questionnaire. A general examination and detailed respiratory system examination were carried out.

Ethical aspects

The present study was conducted in accordance with ethical consideration of the institute, and written informed consent was taken from each employee prior to enroll in the study.

Study participants and sampling

The subjects having diseases which affect the pulmonary functions such as pulmonary tuberculosis, bronchial asthma, chronic bronchitis, emphysema, and other respiratory diseases were excluded. Furthermore, patients with clinical abnormalities of neuromuscular diseases, vertebral column, thoracic cage, who had undergone recent eye, abdominal, or chest surgery, and history of ischemic heart disease were excluded from the study. A total of 332 study participants who were medically fit and could perform spirometry satisfactorily as per the standard procedure were included in the study. The study population was categorized as Group I exposed workers comprised of 240 male participants who engaged in direct surface mining activities whereas Group II comprised of 92 healthy age-matched administrative staff category as non-exposed workers; working fulltime in mine office. There were no any switchers between the groups

Study instruments and measures

Before performing the lung function test, the instrument was calibrated properly and operated at ambient temperature range, and spirometry was conducted as per standard American Thoracic Society/ European Respiratory Society (ATS/ERS) guidelines [12]. The pulmonary function test was carried out by Schiller SP-1 spirometer to measure the lung function capacities of workers. The measured parameters were FVC, FEV1, and the percentage ratio (FEV1/FVC%). All the tests were carried out comfortably in a seated upright position with an applied nose clip during the entire procedure. The participant was instructed to blown out maximally as hard and fast as possible after deep inspiration into the instrument. Meanwhile, participants were encouraged to perform to their optimum level, and after adequate rest, three technically satisfactory results were recorded. The best result was considered for further analysis. Pulmonary function test results were compared with predicted values obtained from the demographic data of the individual participant. The results of the spirometry were interpreted as normal, obstructive, restrictive, or mixed impairment. Measured FVC < 80% of the predictive value is termed as restrictive impairment, FEV1/FVC <70% is termed as obstructive impairment, and combination of RI and OI is termed as mixed impairment [12].

Data analysis

The statistical data were presented as average mean ± SD value for continuous variables, whereas it was as relative frequencies for categorical variables. Analysis between the means of two group variables was compared using independent samples t test, whereas one-way analysis of variance test was applied for multiple comparisons within the groups. Categorical variables were compared by using the Chi-square test. In addition, Pearson's correlation coefficient and linear regression were calculated on the overall mean pulmonary function data against the duration of work exposure. The level of statistical significance was set at $p < 0.05$.

Result and Discussion

The present study was conducted among baryte mine workers to study the impact of mining dust exposure on their pulmonary functions. Spirometry was conducted among 240 exposed and 92 nonexposed workers with the same socioeconomic status. The outcomes of pulmonary indices were affected by the confounding effect of age and height which was associated with the exposure. The regression model of covariates i.e. ANCOVA was used to eliminate or adjust the confounding effect of dependent variables. The confounding effect of age and height was present in all dependent variables and it shows significant differences between the groups except for FEV1/FVC ratio. The result of the study showed that mean FVC was 2.92 and 2.85 and FEV1 was 2.71 and 2.64 among the exposed and nonexposed population, respectively as shown in Table 1. The mean difference between the groups in relation to pulmonary function was statistically significant ($p < 0.01$). A similar observation was also obtained when we compared the pulmonary function impairment between the exposed and non-exposed groups, i.e., it was 15.8% in exposed workers and 6.5% in nonexposed workers, respectively as shown in Table 5.

The duration of work exposure in relation to pulmonary function was analyzed in the exposed group. It was observed that as the duration of exposure increases, the pulmonary function decreases. The FVC decreased from 2.89 to 2.84 to 2.50 as the duration of exposure increases from ≤10 to 11–20 to >20 years, respectively. Similarly, FEV1 decreased from 2.72 to 2.58 to 2.25 and FEV1/FVC (%) also decreased from 93.3% to 91.2% to 88.8% as the duration of exposure increases from ≤10 to 11–20 to >20 years, respectively as represented in Table 2. This decrease in pulmonary function showed highly statistically significant differences among them ($p < 0.001$). In correlation and Regression analysis, r value indicted poor correlation of respiratory lung indices with duration of dust exposure as shown in Table 4.

The pulmonary function parameters were also compared among smokers and nonsmokers of the exposed group as represented in Table 3. It was observed that the mean values of the parameters were lower in smokers, but the difference was statistically insignificant ($p > 0.1$). From the analysis, we observed that the lung capacities of the exposed category were more affected with prolonged working and exposed by mine activities rather than other contributing factor.

The findings of the present study are in line with the other research studies where the miners had lower pulmonary function values as compared to controls and also showed that the duration of exposure to mining activities decreases the pulmonary function capacities. However, there is a difference in

Table 1. Comparison of demographic and lung function parameters between exposed and non-exposed workers.

Parameters	Nonexposed (n = 92)	Exposed (n = 240)	p value
Age (years)	35.9 ± 10.8	37.1 ± 11.6	NS
Height (cm)	166.0 ± 10.7	165.4 ± 5.79	NS
Weight (kg)	71.1 ± 13.6	69.0 ± 11.3	NS
BMI (kg/m^2)	26.4 ± 10.2	25.2 ± 3.65	NS
FVC (lit)	2.92 ± 0.36	2.85 ± 0.25	0.04*
FEV1 (lit)	2.71 ± 0.34	2.64 ± 0.26	0.04*
FEV1/FVC (%)	93.5 ± 9.54	92.8 ± 7.82	NS

lit: Liter.
*Significant; NS = nonsignificant.
This table represents mean values of the demographic and lung function parameters for the exposed and non-exposed population. The mean difference values of lung function parameters, i.e., FVC and FEV1 between the groups were statistically significant, whereas the difference in other parameters was nonsignificant.

Table 2. Comparison of pulmonary function in relation to duration of exposure among exposed workers.

Years of work	FVC (lit)	FEV1 (lit)	FEV1/FVC (%)
≤10 years (*n* = 152)	2.89 ± 0.42	2.72 ± 0.43	93.3 ± 6.80
11–20 years (*n* = 33)	2.84 ± 0.42	2.58 ± 0.41	91.2 ± 7.65
≥20 years (*n* = 55)	2.50 ± 0.46	2.25 ± 0.45	88.8 ± 7.54
F Value	16.8	23.9	8.36
p Value	0.000**	0.000**	0.000**

**Highly significant.
A comparison of pulmonary function parameters of the exposed workers in relation to years of work exposure is shown in this table. It was observed that as the duration of work exposure increases, the measured lung function parameter decreases, and it showed a statistically significant difference among them.

Table 3. Comparison of pulmonary function in relation to smoking habits among exposed workers.

Parameters	FVC (lit)	FEV1 (lit)	FEV1/FVC (%)
Nonsmoker (187)	2.87 ± 0.48	2.67 ± 0.49	92.3 ± 7.44
Smoker (53)	2.84 ± 0.30	2.64 ± 0.35	91.8 ± 7.70
p Value	NS	NS	NS

lit: Liter.
NS = nonsignificant.
This table shows the comparison of pulmonary function in relation to smoking habits among exposed workers. It was observed that the mean values of lung function parameters were lower in smokers as compared to nonsmoker, but the difference was statistically insignificant.

Table 4. Correlation and regression analysis for pulmonary function in relation to duration of work exposure

Parameters	*r* value
FVC (lit)	0.13*
FEV1 (lit)	0.18**
FEV1/FVC (%)	0.05 NS

NS = nonsignificant.
*Significant, ** highly significant.
Correlation and regression analysis of exposed workers for lung function parameters against the duration of work exposure is shown in this table In correlation and regression analysis, *r* value indicted a poor correlation of lung indices, i.e., forced vital capacity, forced expiratory volume in 1 second, and the percentage ratio of forced expiratory volume in 1 second by forced vital capacity (FEV1/FVC%) with duration of dust exposure.

the role of smoking which plays its part in decreasing the pulmonary function capacity of miners. In one longitudinal study among Australian miners, smoking and occupational exposure to lignite dust was significantly associated with a decline in lung function [13]. Another study in Greece revealed a possible interaction between smoking and occupational exposure to lignite dust regarding the impact on lung function [14]. A study in stone quarry workers showed that exposure for longer duration can result in lung function impairment significantly associated with the duration of dust exposure, smoking status, and presence of chronic obstructive airway diseases [15]. Similar findings were reported in quartz stone ex-workers of Gujarat where deterioration in lung function was attributed to the duration of exposure and smoking [16]. A similar pattern was also recorded in studies conducted among coal mine workers. Thus, this study confirms that mine workers are more prone to pulmonary impairment as compared to nonexposed population.

Table 5. Comparison of pulmonary impairment among exposed and nonexposed workers.

Category	Total	Normal PFT	Impaired PFT	X^2	*p* value
Non-exposed	92	86 (93.4)	6 (6.5)		
Exposed	240	202 (84.1)	38 (15.8)	5.01	0.025*
Total	332	288 (86.7)	44 (13.2)		

a. PFT = Pulmonary function test.
*Significant.
The comparison of pulmonary impairment among the exposed and nonexposed workers is shown in this table Pulmonary impairment among study subjects was of restrictive type only. The prevalence of lung impairment among non-exposed workers was found to be 6.5%, whereas in exposed workers, it was 15.8% and the difference among the groups was statistically significant ($p < 0.05$).

Conclusion

The study showed that reduction in pulmonary function parameters such as FVC and FEV1 is directly related to the duration of exposure to dusty environment arising out of mining activities.

Hence, special emphasis should be given to regularly monitor the dust levels and keep it within permissible limits. Awareness about the importance of personal protective devices among the workers will be helpful in mitigating respiratory morbidity.

Limitations

There are certain limitations to this study, one of the limitations is that it is a small sample size cross section study, there is a need to conduct large scale study to explore greater and detail scenario of prevalence of occupational diseases and its associated factor. In addition to this, there may be variability across epidemiological studies in terms of data collection and analyses. Also recruitment criteria, self reported duration of exposure, variability in spirometry technique and other risk factor that could influence the phenomenon. It would have been better if we could measure dust concentration or dust exposure assessment with time trends on pulmonary functions of workers. It would better demonstrate cause and effect relationship.

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