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Comparative study of pulmonary impairment among diverse working groups in coal mine

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ABSTRACT

Aim: There are different categories of workers depending upon their involvement in mining operation who are exposed to different levels of dust and for different durations. The occurrence and degree pulmonary impairment may differ among different workers in the same mining environment. The aim of the study was to evaluate and compare the respiratory function parameters of actively engaged exposed mine workers to that of supportive workers with respect to their duration of work exposure.
Methods: 207 workers from coal mine were divided into two groups as per job profile. Group 1 consisting of 115 workers engaged in active mining operations and Group 2 consisting of 92 workers not continuously exposed to mining operations during their working hours. The lung functions of the workers were assessed by using Spirometer. ANOVA and Independent "*t*" test were used *p* value of ≤0.05 was considered as statistically significant.
Result: Lung parameters, i.e., forced vital capacity, forced expiratory volume in one second, and forced expiratory flow (25–75%) were significantly reduced among Group 1 workers except for peak expiratory flow rate which was non-significantly reduced. The differences among the parameters of lung function were statistically significant with exposure <30 years of work; however, the difference was insignificant >30 years of exposure.
Conclusion: Pulmonary impairment is more evident in early years among the mine worker actively engaged in mining operations as compared to workers engaged in allied mining operation as the level of exposure to dust varies largely. However, after long-term exposure the impairment of allied workers is also in line with that of actively engaged mine workers.

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Pulmonary impairment; degree of exposure; lung function; spirometry; smoking

Introduction

Coal is an important energy source for many human and industrial activities. India is one of the largest producers of coal with abundant coal reserves widely spread throughout the country [1]. More than 4 lacs of miners are working in coal mines [2]. These mine workers are exposed to various physical and chemical hazards during their working environment of which dust-related health hazards still remain the most common occupational health problem. During mining operations such as drilling, blasting, crushing, grinding, milling, sawing, and polishing, a large amount of dust is dispersed in air [3,4] and inhalation of these dust particles irritate and set up an inflammatory reaction in airways leading to defective oxygen diffusion and impaired lung function [5]. To detect this pulmonary impairment, spirometry is one of the most important diagnostic tools which assess various lung function parameters among workers exposed to dust. It is a preferred tool for health surveillance as it is inexpensive, non-invasive, and causes minimum discomfort to the subject. It gives information about decrease in lung volume and the type of respiratory impairment. There are different categories of workers depending upon their involvement in mining operation. Hence, these workers are exposed to different levels of dust and for different

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time durations of exposure. Therefore, it may be assumed that both the occurrence and degree pulmonary impairment will differ in different workers in the same mining environment. The present study was undertaken to evaluate and compare the respiratory functions of actively engaged exposed mine workers to that of supportive workers with respect to their duration of work exposure.

Material and Methods

The study was conducted in accordance with ethical guidelines among workers engaged in coal mining operation belonging to age group of 22–60 years with same socio-demographic status. The information regarding their height weight, blood pressure, smoking, occupation, and illness history was recorded. General examination and detailed respiratory system examination was carried out. The subjects having diseases which affect the pulmonary functions such as pulmonary tuberculosis, bronchial asthma, chronic bronchitis, emphysema, and other respiratory diseases were excluded. Also, patients with clinical abnormalities of neuromuscular diseases, vertebral column, thoracic cage, and who had undergone recent eye surgery, abdominal, or chest surgery, and with the history of ischemic heart disease were excluded from the study. A total of 207 study subjects who were fit to perform spirometry satisfactorily as per standard procedure were included in the study.

The study population was divided into two groups according to their job profile. Group 1 consisting of 115 workers from mining department engaged in active mining operations during their working hours like loader, blaster, etc., and Group 2 consisting of 92 workers like from electrical and mechanical department engaged in related supportive work not continuously exposed to mining operations during their working hours. The lung functions of the workers were assessed using Spirometer.

Spirometer was calibrated and operated at ambient temp range and spirometry was conducted as per standard procedure [6]. The parameters measured included forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), peak expiratory flow rate (PEFR), and forced expiratory flow ($FEF_{25\%–75\%}$). The subject was seated in an upright position with a nose clip applied during the entire procedure. The subject was instructed to blow out maximally after deep inspiration. While performing the test, the subjects were encouraged to perform to their optimum level and after adequate rest three technically satisfactory results were recorded. The best result was considered for analysis. Pulmonary function test results were calculated from the standard prediction equation.

Statistical Analysis

The data of pulmonary function tests were presented as the Mean ± SD for each of the parameters. Statistical analysis was done by applying comparison tests of significance such as One Way Analysis (ANOVA) test and independent "*t*" test. Significant *p* value (≤0.05) and (≤0.005) were considered as statistically significant and highly significant values, respectively.

Result

The demographic characteristics of average mean ± SD values of age (year), height (cm), weight (kg), body mass index (BMI, kg/m^2), and length of dust exposure (year) of both the groups are presented in Table 1. From the inter-group comparison, pulmonary function test has revealed that by applying the independent *t*-test the average mean ± SD values of all the lung parameters, i.e., FVC, FEV_1, and $FEF_{25\%–75\%}$ were significantly reduced among Group 1 workers except for PEFR which was non-significantly reduced as shown in Table 2. Both the groups were compared to study impact of work exposure on their pulmonary function parameters for exposure of ≤30 years and >30 years as shown in Table 3.

The smokers and nonsmokers among both the groups were compared and it was observed that the values of all the parameters were lowered in smokers as compared to nonsmokers in both the groups but only PEFR was statistically significant in Group 1 as shown in Table 4.

Discussion

Mining is one of the most dusty occupations. The mine workers are highly exposed to respirable

Table 1. Demographic characteristics of the coal mine workers.

Parameters	Group-I (*n* = 115)	Group-II (*n* = 92)
Age (years)	52.3 ± 6.29	49.4 ± 9.41
Height (cm)	164.0 ± 6.53	165.0 ± 6.67
Weight (kg)	68.6 ± 13.2	65.4 ± 9.98
BMI (kg/m^2)	25.3 ± 4.00	24.1 ± 3.60
Work-exposure (years)	29.4 ± 6.00	25.7 ± 9.43

Table 2. Inter-group comparison of coal miners in relation to ventilatory function test.

Parameters	Group-I (*n* = 115)	Group-II (*n* = 92)	*p*-value
FVC (L)	2.68 ± 0.28	2.78 ± 0.38	0.0472*
FEV_1 (L)	2.33 ± 0.32	2.47 ± 0.35	0.0042**
FVC (L)/FEV_1(L)	87.27 ± 7.58	88.99 ± 5.82	0.0214*
PEFR (L/sec)	5.94 ± 1.46	5.84 ± 1.60	0.6239 (NS)
FEF (L)	2.92 ± 0.96	3.19 ± 0.82	0.03215*

*p = 0.05 significant, **p = 0.005 highly significant and FVC: Forced vital capacity, FEV_1: Forced expiratory volume in one second, PEFR: Peak expiratory flow rate, NS: Non-significant, and FEF: Forced expiratory flow.

Table 3. Inter-group comparison of pulmonary function in relation to work exposure.

Factors	FVC (L)	FEV_1 (L)	PEFR (L/sec)	FEF (L)
Group-I (47)	2.63 ± 0.28	2.30 ± 0.30	6.14 ± 1.56	2.93 ± 0.95
Group-II (47)	2.81 ± 0.37	2.50 ± 0.33	5.76 ± 1.48	3.24 ± 0.87
p value	0.0097*	0.0041**	0.2335 (NS)	0.1075 (NS)
Group-I (68)	2.71 ± 0.28	2.36 ± 0.33	5.81 ± 1.37	2.91 ± 0.98
Group-II (45)	2.74 ± 0.39	2.44 ± 0.36	5.92 ± 1.72	3.13 ± 0.77
p value	0.7195 (NS)	0.1987 (NS)	0.7196 (NS)	0.1807 (NS)

*p = 0.05 significant, **p = 0.005 highly significant and FVC: Forced vital capacity, FEV_1: Forced expiratory volume in one second, PEFR: Peak expiratory flow rate, FEF: Forced expiratory flow, and NS: Non-significant.

dust concentration during mining activity at their workplace. Initially the defense mechanism of the body tries to get rid of the dust from the lungs; however, after continuous exposure for longer duration causes accumulation in lung as body fails to clear the excess amount of dust getting continuously accumulated. The body reaction to clear this accumulated dust results in release of proteolytic enzymes causing proliferation of connective tissue leading to impairment of the lung functions of the exposed workers [7]. The present study was conducted in coal mines to compare lung impairment among the coal mine workers actively engaged in mining operations as compared to that to workers engaged in allied mining operations as both the workers are exposed to mining environment but the level of exposure to dust varies largely.

It was observed that both the groups were comparable with mean age around 50 years and work exposure more than 25 years.

The outcomes of lung indices were affected by the confounding effect of, i.e., age and height, which was associated with the exposure. Hence, in this context analysis of variance, i.e., Analysis of Covariance (ANCOVA) was used to improve the effect size of an experiment and also to eliminate the covariate effect. The values of different dependent variables were adjusted by using regression model of covariates, i.e., ANCOVA after eliminating the confounding effect.

On comparison of various parameters of pulmonary functions, it was observed that FVC, FEV_1, and $FEF_{25\%-75\%}$ were significantly decreases in Group 1, i.e., active mine workers. The deterioration of lung parameters observed in active mine workers of the study is consistent with several previous studies [8–18]. To ascertain whether the difference is related to duration of exposure, the two groups were compared with work exposure <30 years and >30 years. It was observed that the difference among the parameters were statistically significant with exposure <30 years

Table 4. Comparison of pulmonary function in relation to smoking.

Factors	Work experience ≤ 30				Work experience > 30			
	FVC (L)	FEV_1 (L)	PEFR (L/sec)	FEF (L)	FVC (L)	FEV_1 (L)	PEFR (L/sec)	FEF (L)
Group-I								
Non-smoker	2.63 ± 0.28	2.31 ± 0.25	6.35 ± 1.72	2.97 ± 0.92	2.74 ± 0.27	2.40 ± 0.31	5.96 ± 1.54	3.03 ± 0.98
Smoker	2.77 ± 0.25	2.36 ± 0.38	5.38 ± 1.28	2.74 ± 0.94	2.78 ± 0.20	2.34 ± 0.34	4.97 ± 1.14	2.68 ± 0.89
Ex-smoker	2.51 ± 0.30	2.21 ± 0.42	6.00 ± 1.05	2.96 ± 1.15	2.59 ± 0.33	2.25 ± 0.39	5.22 ± 0.26	2.74 ± 1.04
p value	0.472 (NS)	0.488 (NS)	0.369 (NS)	0.888 (NS)	0.105 (NS)	0.155 (NS)	0.0304*	0.255 (NS)
Group-II								
Non-smoker	2.84 ± 0.36	2.53 ± 0.34	6.04 ± 1.45	3.29 ± 0.87	2.74 ± 0.40	2.44 ± 0.37	5.92 ± 1.83	3.21 ± 0.81
Smoker	2.73 ± 0.45	2.40 ± 0.33	5.89 ± 1.03	3.17 ± 0.95	2.86 ± 0.37	2.59 ± 0.25	5.81 ± 1.31	3.13 ± 0.33
Ex-smoker	2.58 ± 0.00	2.25 ± 0.01	5.11 ± 1.18	2.53 ± 0.00	2.60 ± 0.40	2.28 ± 0.41	6.05 ± 1.85	2.78 ± 0.92
p value	0.843 (NS)	0.704 (NS)	0.121 (NS)	0.311 (NS)	0.641 (NS)	0.534 (NS)	0.922 (NS)	0.216 (NS)

*p = 0.05 significant, and FVC: Forced vital capacity, FEV_1: Forced expiratory volume in one second, PEFR: Peak expiratory flow rate, FEF: Forced expiratory flow, and NS: Non-significant.

of work; however, the difference was insignificant >30 years of exposure. This indicates that the pulmonary impairment among active mine workers is more evident in earlier years. However, after long exposure the impairment of allied workers also gets affected in line with that of active mine workers. This may explain that dust does play a role in impairment of pulmonary function of both kinds of mine workers. As active mine workers are exposed to high level of dust compared to that of allied workers, the impairment happens earlier.

Smoking is widely recognized as a risk factor leading to the obstructive type of respiratory impairment [19–21]. Several epidemiological studies explored the relation of prolonged coal dust exposure with combined tobacco smoke effect on respiratory functions of exposed workers showed markedly decreased ventilatory indices of workers [22–24]. To determine the role of this confounding factor, both the groups were further compared according to their smoking habits. It is observed that values of all the parameters were lowered in smokers as compared to nonsmokers in both the groups but only PEFR was statistically significant in group 1 with exposure of >30 years. It may be concluded that smoking has additive role with dust in impairment of lung functions.

Conclusion

The present study showed that the degree of pulmonary impairment is more evident in early years among the mine workers actively engaged in mining operations as compared to the workers engaged in allied mining operation as the level of exposure to dust varies largely. However, after long-term exposure the impairment of allied workers is also in line with that of actively engaged mine workers.

References

[1] Ministry of Coal. Coal mining in India. Available via http://coal.nic.in/content/coal-mining-india (Accessed 10 April 2016).

[2] Ministry of Coal. Annual Report 14–15. Available via http://coal.nic.in/sites/upload_files/coal/files/coalupload/chap5AnnualReport1415en.pdf (Accessed 10 April 2016).

[3] Baker D, Nieuwenhuijsen MJ. Environmental epidemiology: study methods and application. Oxford University Press, New York, NY, 2008.

[4] Schreiber J, Koschel D, Kekow J, Waldburg N, Goette A, Merget R. Rheumatoid pneumoconiosis (Caplan's syndrome). Eur J Intern Med 2010; 21(3):168–72.

[5] Fujimura N. Pathology and pathophysiology of pneumoconiosis. Curr Opin Pulm Med 2000; 6(2):140–4.

[6] Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardization of spirometry. Eur Respir J 2005; 26:319–38.

[7] Wallart B, Leroy S. Silicosis & coal workers pneumoconioses. In: Albert RK, Spiro SG, Jett JR (eds) Clinical respiratory medicine. 3rd edition, Mosby, Philadelphia, PA, pp 809–15, 2008.

[8] Raju AE, Jhansi K, Amruta K, Sayyad R, Munisekhar K. A study on pulmonary function tests in coal mine workers in Khammam District, Telangana–India. Int J Physiother Res 2014; 2(3):502–6.

[9] Chandrasekaran V, Dilara K, Padavathi R. Pulmonary functions in tannery workers: a cross sectional study. Indian J Physiol Pharmacol 2014; 58(3):205–9.

[10] Dhillon SK, Bassi R, Kaur H. A study of lung function abnormalities in workers of Rice Mills. Indian J Fundam Appl Life Sci 2011; 1(3):217–20.

[11] Nikhade NS, Sharma P. A study of pulmonary function test in workers of sugar factory, Pravaranagar, Maharashtra. Int J Med Res Health Sci 2012; 2(1):52–8.

[12] Koo JW, Chung CK, Park CY, Lee S, Lee K, Roh Y, et al. The effect of silica dust on ventilatory function of foundry workers. J Occup Health 2000; 42:251–7.

[13] Sahu S, Roy B, Moitra S. Assessment of the lung function status of the goldsmiths working in an unorganized sector of India. Lung India 2013; 30:33–7.

[14] Aida NA, Juliana J. Exposure to PM10 and lung function among welders of metal working factory in Selangor. Health Environ J 2014; 5(1):113–25.

[15] Prathapan S, Hettiarachchi P, Wimalasekara SW. Respiratory illness and ventilatory function among gem cutters in Sri-Lanka. Ceylon Med J 2013; 58:29–31.

[16] Kumar CHK, Reddy MN, Singh SBM, Krishna B, Sasikala P, Shravyakeerthi G, et al. Deterioration of pulmonary function in stone quarry workers. Biomed Res 2014; 25(2):261–6.

[17] Neghab M, Mohraz MH, Hassanzadeh J. Symptoms of respiratory disease and lung function impairment associated with occupational inhalation exposure to carbon black dust. J Occup Health 2011; 53:432–8.

[18] Harbison SC, Johnson GT, McCluskey JD, Xu P, Mohammad S, Wolfson J, et al. Occupational health surveillance: pulmonary function testing in utility workers. J Clinic Toxicol 2012; S5–006:1–4.

[19] Wang ML, Wu ZE, Du QG, Petsonk EL, Peng KL, Li YD, et al. A prospective cohort study among new Chinese coal miners: the early pattern of lung function changes. Occup Environ Med 2005; 62:800–5.

[20] Wang ML, Petsonk EL, Beeckman LA, Wagner GR. Clinically important FEV_1 declines among coal miners: an exploration of previously unrecognized determinants. Occup Environ Med 1999; 56:837–44.

[21] Mahfuz M, Ahmed T, Ahmad SA, Khan MH. Altered pulmonary function among the transport workers in Dhaka city. Health 2014; 6:2144–53.
[22] Sterling GM. Mechanism of bronchoconstriction caused by cigarette smoking. Br Med J 1967; 3:275–7.
[23] Chung CK. Effect of smoking on airway resistance of normal subjects. J Catholic Medical College 1972; 23:93–104.
[24] Tager IB, Segal MR, Speizer FE. Effect of cigarette smoking and respiratory symptoms. Am Rev Respir Dis 1988; 138:837–49.