Dust Exposure and Lung Function Impairment in Construction Workers

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Abstract

Background: Millions of people are working daily in dusty environment. They are exposed to different types of occupational health hazards such as fumes, gases, organic and inorganic dusts which are risk factors in developing occupational lung diseases. Workers engaged in building and construction work are at risk of developing impaired lung function due to exposure to high level of dust generated at the construction site.

Aims: The present study was designed to assess the effect of exposure to various types of dust in construction site on lung functions of construction workers.

Materials and methods: The lung function was studied in 61 male construction workers and 62 male control subjects. All the participants were nonsmokers. The subjects were matched for age, height and weight. The pulmonary function test was performed by using an electronic spirometer and results were compared by Student's unpaired *t* test.

Results: The results of the present study showed a significant decrease in the mean values and percent predicted value of FVC, FEV_1, $\%FEV_1/FVC$, PEFR and $FEF_{25\text{-}75\%}$ in construction workers and this impairment was increased with duration of exposure to dust in construction site.

Conclusion: Based on the results of the present study it may be concluded that construction workers in India are at increased risk of developing occupationally related pulmonary impairment. We recommend the compulsory use of personal protective equipment by construction workers during work.

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Keywords: *pulmonary function test, FVC, FEV_1, PEFR, construction workers*

The workplace environment affects the health of workers. Individuals working in dusty environment face the risk of inhaling particulate materials that may lead to adverse respiratory effects.[1] The occupationally related lung diseases are most likely due to the deposition of dust in the lung and are influenced by the sort of dusts, the period of exposure, the concentration and size of the airborne dust in the breathing zone.[2] Reduction in lung function has been reported in cotton workers, coal miners, grain and flour mill workers, workers exposed to tobacco dust, barley dust, talc dust and in quarry workers,[3] but no study has been reported in workers engaged in building and construction work in India. All construction sites generate high level of dust typically from concrete, silica, asbestos, cement, wood, stone, sand etc. Construction dust is classified as PM-10, i.e. particulate matter of less than 10 μm diameter, and workers are at risk of inhaling these particles. Silica is a mineral found in the earth's crust. Airborne silica dust is generated during chasing or drilling into concrete, brick work, ripping up old concrete, excavating sites with sandstone or clay. Workers are exposed to this airborne dust in construction site.[4] Percentage of crystalline silica in construction and building materials are sand and sandstone 96-100%, calcium silicate brick 50-55%, aggregate concrete 30%, clay brick 15-27%, cement sheet 10-30%, demolition dust 3-4% and it is present considerably in cement dust also.[5] Exposure to silica can cause chronic bronchitis, emphysema, acute and chronic silicosis, lung cancer etc.[6] Cement dust causes mucous hypersecretion initially, followed by lung function impairment, chronic obstructive lung disease, restrictive lung disease and pneumoconiosis etc.[6,7]

Dust particles which are inhaled and lodged in the lung irritate and set up an inflammatory reaction. Healing of this inflammation causes fibrosis leading to defective oxygen diffusion and impaired lung function.[6]

In occupational respiratory diseases, spirometry is one of the most important diagnostic tools. It plays a significant role in the diagnosis and prognosis of these diseases and describes the effect of restriction or obstruction on the lung function.[8] Periodic testing in workers can detect pulmonary disease in its earlier stages when corrective measures are more likely to be beneficial. In view of the fact that various airborne particulate dust puts the worker's health into jeopardy and most of the workers in India do not use protective measures and no earlier study in these construction workers has been reported, this study was undertaken to assess the effect of dust exposure on lung function of construction workers. Further the relationship between the pulmonary function impairment and duration of exposure has not been analyzed earlier so this study was also designed to investigate the effect of duration of dust exposure and the lung function of the construction workers.

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Table 1 Anthropometric parameters of construction workers compared with their matched controls

Groups		n	Age (yrs)	Height (cm)	Weight (Kg)
Control subjects		20	25.20 ± 0.59	159.65 ± 1.34	60.50 ±1.15
Construction workers (1-5 years)		20	25.87 ± 0.77	163.47 ± 0.67	62.47 ± 1.41
Significance	*t* value*		0.70	2.30	1.09
	P value		0.49 NS	0.03 S	0.28 NS
Control subjects		20	33.35 ± 1.29	163.05 ± 1.58	62.75 ± 1.19
Construction worker (6-10 years)		20	36.35 ± 1.24	165.15 ± 1.58	62.20 ± 1.97
Significance	*t* value*		1.68	0.71	0.24
	P value		0.10 NS	0.48 NS	0.81 NS
Control subjects		22	34.36 ± 5.86	163.73 ± 6.85	63.50 ± 5.40
Construction workers >10 years		21	35.0 ± 6.77	163.86 ± 9.71	61.24 ± 4.05
Significance	*t* value*		0.74	0.95	0.12
	P value		0.46 NS	0.37 NS	0.90 NS

Values are mean ± SD. *Unpaired *t* test; NS, not significant ($P > 0.05$); S, significant ($P < 0.01$); HS, highly significant ($P < 0.001$).

Materials and Methods

The study was undertaken in 61 healthy male subjects employed in building and construction work like masonry, mixing the concrete, plastering etc., age ranging from 20 to 50 years. These workers worked for at least 6-8 hours a day for 6 days a week. Sixty-two apparently healthy male, control subjects were also selected. All subjects were matched for age, height and weight and all were nonsmokers. Subjects with clinical abnormalities of vertebral column and thoracic cage, anemia, diabetes mellitus, hypertension, pulmonary tuberculosis, bronchial asthma, chronic bronchitis, emphysema and other respiratory diseases and subjects who had undergone abdominal or chest surgery were excluded from the study.

Spirometry was performed on a computerized RMS medspiror. The spirometer has a mouthpiece attached to a transducer assembly which is connected to an adaptor box, and this is connected to the computer by a serial cable. Software from recorders and medicare system is loaded on to the computer. This software allows the calculation of the predicted values for age, sex, weight and height and it also gives the recorded values of all the parameters adjusted for Indian population. All pulmonary function tests were carried out at a fixed time of the day (9.30-12 noon) to minimize any diurnal variation. After taking a detailed history and anthropometric data, the lung function tests were done. Subjects were motivated prior to the start of the maneuver and written consent was obtained. The test was performed and repeated three times after adequate rest and the results obtained were available in the spirometer. The parameters were forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), forced expiratory ratio (% FEV_1/FVC), peak expiratory flow rate (PEFR) and forced expiratory flow ($FEF_{25-75\%}$).

Statistical analysis

The results are presented as mean ± SD and percentage difference. Unpaired *t* test was used for groupwise comparisons. *P* value of 0.05 or less was considered for statistical significance.

Results

For the purpose of analysis of data, the results are tabulated according to the duration of exposure to dust (1-5 years, 6-10 years and more than 10 years). The statistical comparisons of the matching variables (age, height and weight) are inherently similar for the two groups and hence statistical confirmation of this fact is not discussed (Table 1). All pulmonary function parameters are presented and compared in both mean values and percent predicted values adjusted by race, gender, height and age.

Table 2 summarizes the comparison of lung function parameters in construction workers who are exposed for 1-5 years and their matched control group. There was no

Table 2 Lung function data in construction workers with exposure duration of 1-5 years, compared with their matched controls

Parameters	Actual value		Significance		Percent predicted		Percent difference (%)	Significance	
	Control subjects (n = 20)	Construction workers (n = 20)	*t* value*	*P* value	Control subjects (n = 20)	Construction workers (n = 20)		*t* value*	*P* value
FVC (L)	3.28 ± 0.11	3.08 ± 0.05	1.55	0.13 NS	97.35 ± 4.43	90.60 ± 6.62	6.93	0.09	0.92 NS
FEV_1 (L)	2.82 ± 0.08	2.64 ± 0.05	1.75	0.09 NS	94.7 ± 5.33	87.53 ± 6.03	7.57	0.07	0.94 NS
%FEV_1/ FVC(%)	86.14 ± 0.49	85.59 ± 0.49	0.95	0.35 NS	99.8 ± 1.43	95.33 ± 6.86	4.48	0.007	0.99 NS
PEFR (L/s)	8.46 ± 0.19	8.20 ± 0.16	1.00	0.32 NS	93.8 ± 5.09	92.33 ± 5.57	1.56	0.42	0.67 NS
$FEF_{25-75\%}$ (L/s)	4.48 ± 0.06	4.43 ± 0.09	0.47	0.64 NS	97.35 ± 7.32	96.33 ± 9.22	1.04	0.71	0.48 NS

Values are mean ± SD. *Unpaired *t* test; NS, not significant ($P > 0.05$); S, significant ($P < 0.01$); HS, highly significant ($P < 0.001$).

Table 3 Lung function data in construction workers with exposure duration of 6-10 years, compared with their matched controls

Parameters	Actual value		Significance		Percent predicted		Percent difference (%)	Significance	
	Control subjects (n = 20)	Construction workers (n = 20)	*t* value*	*P* value	Control subjects (n = 20)	Construction workers (n = 20)		*t* value*	*P* value
FVC (L)	3.18 ± 0.09	2.73 ± 0.07	3.88	< 0.001 HS	93.15 ± 4.94	78.10 ± 5.78	16.16	9.23	< 0.001 HS
FEV_1 (L)	2.72 ± 0.08	2.17 ± 0.07	3.21	< 0.01 S	87.60 ± 6.61	70.74 ± 3.29	8.97	2.80	< 0.01 S
$\%FEV_1$/ FVC (%)	85.37 ± 0.50	78.4 ± 5.57	7.7	< 0.001 HS	88.65 ± 7.13	73.0 ± 10.24	17.26	2.88	< 0.01 S
PEFR (L/s)	7.91 ± 0.18	7.11 ± 0.31	2.26	< 0.05 S	88.10 ± 4.25	78.0 ± 8.90	11.01	8.52	< 0.001 HS
$FEF_{25-75\%}$ (L/s)	4.25 ± 0.23	4.16 ± 0.10	0.35	0.73 NS	99.20 ± 7.68	76.80 ± 7.36	22.58	1.76	0.09 NS

Values are mean ± SD. *Unpaired *t* test; NS, not significant ($P > 0.05$); S, significant ($P < 0.01$); HS, highly significant ($P < 0.001$).

Table 4 Lung function data in construction workers with exposure duration of more than 10 years, compared with their matched controls

Parameters	Actual value		Significance		Percent predicted		Percent difference (%)	Significance	
	Control subjects (n = 22)	Construction workers (n = 21)	*t* value*	*P* value	Control subjects (n = 22)	Construction workers (n = 21)		*t* value*	*P* value
FVC (L)	3.16 ± 0.42	2.01 ± 0.15	4.57	<0.001 HS	90.35 ± 3.88	65.95 ± 6.55	27.00	4.66	<0.001 HS
FEV_1 (L)	2.67 ± 0.32	1.66 ± 0.32	9.50	<0.001 HS	86.5 ± 6.56	59.28 ± 3.80	31.46	4.63	<0.001 HS
$\%FEV_1$/ FVC (%)	84.75 ± 2.23	75.47 ± 5.42	3.91	<0.001 HS	84.95 ± 7.82	72 ± 5.66	15.36	3.29	<0.001 HS
PEFR (L/s)	7.70 ± 0.60	5.71 ± 1.26	5.26	<0.001 HS	89.50 ± 5.60	67.19 ± 11.23	24.93	9.89	<0.001 HS
$FEF_{25-75\%}$ (L/s)	4.15 ± 0.50	3.03 ± 0.72	4.95	<0.001 HS	99.2 ± 7.68	72.40 ± 13.50	27.01	4.25	<0.001 HS

Values are mean ± SD. *Unpaired *t* test; NS, not significant ($P > 0.05$); S, significant ($P < 0.01$); HS, highly significant ($P < 0.001$).

significant difference between the two groups in both mean values and the percent predicted values of any lung function data. The mean duration of exposure was 2.93 ± 1.48 years (range 1-5 years).

Building construction workers exposed for 6-10 years showed a significant reduction in percent predicted values and mean values of FVC, FEV_1, $\%FEV_1$/FVC and PEFR when compared with their matched controls (Table 3), but these workers did not show a statistically significant reduction in $FEF_{25-75\%}$ relative to controls even though the actual value is decreased. The percentage change in the construction worker's data relative to controls was also significantly decreased for FVC, FEV_1, $\%FEV_1$/FVC, $FEF_{25-75\%}$ and PEFR. The mean duration of exposure was 7.3 ± 0.97 years (range 6-10 years).

Construction workers exposed for more than 10 years showed a statistically significant decrease in percent predicted values and mean values of FVC, FEV_1, $\%FEV_1$/FVC, PEFR and $FEF_{25-75\%}$ (Table 4). The percentage change in the worker's data relative to controls was materially decreased for FVC, FEV_1, $\%FEV_1$/FVC, PEFR and $FEF_{25-75\%}$. The mean duration of exposure was 14.66 ± 2.35 years. The comparison between the various pulmonary function parameters and duration of exposure was shown in Figure1.

Discussion

Occupational respiratory diseases are usually caused by extended exposure to irritating or toxic substances that may cause acute or chronic respiratory ailments.[1] The incidence depends upon the chemical composition of dust, size of the particles,duration of exposure and individual susceptibility.[6]

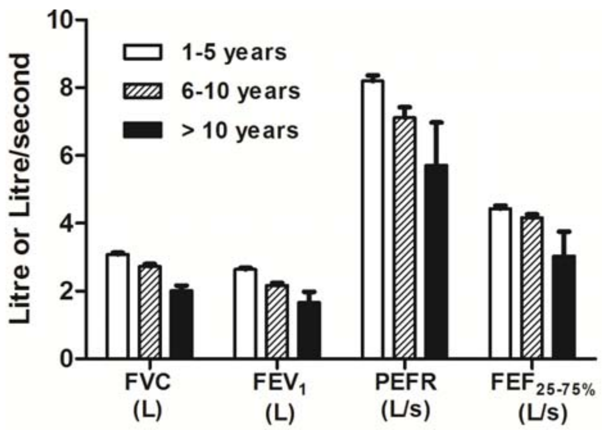

Figure 1 Comparison of lung function parameters and duration of exposure. Error bars are standard deviations.

Dust originating from work operation like drilling, blasting and grinding becomes airborne and inhalation of particles may induce accelerated lung function decline.[9]

When airborne dusts are inhaled, scavenger cells like macrophages dissolve the dust particles by surrounding them. But if there is too much dust and overload situation the scavenger cells cannot completely clear the dust. They lodge in and irritate the lungs setting up an inflammation in the small air tubes and sacs of the lungs. As the inflammation heals it leaves a scar tissue called fibrosis. In the lung this fibrosis causes the lining of the air sacs to thicken so that it is hard for oxygen to pass from the air into the blood stream, slowly as the scarring progress the workers begin to suffocate.[5,6]

In construction site even though the workers are exposed to various dusts, the concentration of exposure is less compared to workers in cement factory, quarry workers, and tunnel workers. The present study was designed to investigate the dose response of years of exposure to dust in construction site on lung function. It shows an association between pulmonary function impairment and duration of exposure.

In addition, while conducting this kind of studies little consideration has been given to promising factors which affect the lung function such as age, height, weight, smoking. Therefore the study was designed to investigate the effects of airborne dusts on the lung function of construction workers matched for age, height and weight.

In our study the results showed that the workers with less than 5 years exposure did not have much impairment in lung function compared to the controls. The workers exposed for 6-10 years showed reduction in lung function and above 10 years showed a further reduction in pulmonary function.[6] It is consistent with the fact that low concentration of silica exposure takes usually more than 10 years to develop chronic silicosis. Increased duration of working at construction site increases the lung damage causing both airway obstruction and interstitial involvement.

L. Christine Oliver and his colleagues studied the lung function of workers in highway construction work and found that FEV_1 in these workers are lower than the predicted value and are at increased risk for asthma.[10] Krzyzanowski and his co-workers conducted a study among workers who are exposed to dust found in building material and in pottery industry and found an annual rate of decline in FEV_1 to occupational exposure.[11] Bakke and his colleagues observed an annual decrease of 21 ml of FEV_1 in low silica dust exposed nonsmokers in the lung function of the tunnel construction workers.[12] Ulvestad et al conducted a study to find out association between dust exposure and airway inflammation and found lower airway inflammation even though they worked for only 1 year.[9] The results of the present study also showed a decreased FEV_1 which is in agreement with the observations made by those authors.

Green et al demonstrated the effect of long term exposure to mineral dust in young Indian adults and showed that FVC was significantly lower in this group compared to control group.[13] Bagatin et al analyzed the influence of exposure time to silica on pulmonary function of stone quarry workers and found that the FVC, FEV_1, $\%FEV_1/FVC$ are reduced in exposure group and peripheral airways are involved first and if the duration of exposure is increased, large airways are also involved.[14]

Chia K.S and his co-workers in their study showed that small airway obstruction is seen in the absence of radio-logical evidence.[15]

Chun Yuh Yang et al assessed the relationship between cement dust exposure and ventilatory function in the workers and showed that cement dust may lead to high prevalence of chronic respiratory disease and the reduction of ventilatory capacities. They found out that the exposed workers had reduced FVC, FEV_1 and $FEF_{25-75\%}$.[16]

Al-Neaimi and his colleagues showed that ventilatory functions like FVC, FEV_1, $\%FEV_1/FVC$ and PEFR were significantly reduced in the workers at a cement factory in a rapidly developing country.[17] Mathur ML reported a decrease PEFR in the workers exposed to silica than the same in the healthy adults.[18] Mark Purde et al found that impaired lung function which may be obstructive or restrictive are associated with dust exposure in the construction workers.[19]

While considering the pathophysiological aspects of a drop in the values of the aforesaid lung function parameters, FVC is decreased in pulmonary obstruction, emphysema, pleural effusion, pneumothorax, pulmonary edema and poliomyelitis. Similarly, the FEV_1 value is low in obstructive lung diseases and in reduced lung volume.[20] The decline in FEV_1 is a convenient standard against which we can measure marked declines in subjects with the history of chronic obstructive pulmonary disease (COPD) or in subjects exposed to environmental pollutants, whereas PEFR provides an objective assessment of functional changes associated with environmental and occupational exposures and determines acute or chronic disease processes in patients with severe COPD.[20] PEFR is persistently low and represents collapsing of large airways.[20] In view of pathophysiological aspects and a drop in the lung parameters, our results suggest that dusts in construction site affect the lung functions. A decrease in the lung function parameters like FVC, FEV_1, $\%FEV_1/FVC$, PEFR and $FEF_{25-75\%}$ showed that these parameters are very sensitive in detecting changes in pulmonary function at an early stage.

Conclusion

The present study concluded that airborne particulate materials in the construction site adversely affect the pulmonary function parameters like FVC, FEV_1, $\%FEV_1/FVC$, PEFR and $FEF_{25-75\%}$ in the construction workers and cause an obstructive pattern of lung function impairment which is associated with the dose effects of years of exposure to airborne dust in construction site. We recommended that workers should use protective face mask during work, use water through the drill stem, use saw that provides water to the blade, use wet sweeping instead of dry sweeping, wet down dusty areas and processes and do not smoke as smoking reduces the lung's ability to clear dust and increases the risk of lung cancer.

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Conflict of Interest

None to declare.

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