PULMONARY FUNCTION TESTS OF FEMALES WORKING AT CONSTRUCTION SITES

Neera Goel¹, Niraj Kumar Yadav²

¹Associate Professor, Department of Physiology, GS Medical College and Hospital, Hapur, Uttar Pradesh.

²Tutor, Department of Community Medicine, GS Medical College and Hospital, Hapur, Uttar Pradesh.

ABSTRACT

BACKGROUND

Respiratory disorders are among the most common occupational diseases. Millions of people are working daily in dusty environment. They are exposed to various types of occupational health hazards such as gases, fumes, inorganic and organic dusts which have 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 and Objectives- This study aimed to assess the effect of exposure to various types of dust at construction site on pulmonary functions of female construction workers.

MATERIALS AND METHODS

The pulmonary function test was studied in 110 female construction workers and 110 female control subjects. The subjects were matched for age, height and weight. The Forced Vital Capacity (FVC) measured by simple spirometer and Peak Expiratory Flow Rate (PEFR) by Wright, peak flow meter and results were compared by student's unpaired 't' test.

RESULTS

The results of the present study showed a significant decrease in observed FVC Group 3, 4 and 5, % FVC in Group 4 and 5, PEFR in Group 4 and 5, and % PEFR shows significant decrease in Group 3, 4 and 5 of female construction workers. FVC and PEFR are lower than the predictive value in all the groups of female construction workers. Female construction workers showed development of obstructive type of lung function impairment after 9 years of work and restrictive type of lung function impairment after 15 years of work.

CONCLUSION

Based on the results of the present study, it may be concluded that female construction workers in India are at increased risk of developing occupation related pulmonary impairment. We recommend they should use protective equipment during work.

KEYWORDS

Pulmonary Function Test, FVC, % FVC, PEFR, % PEFR, Female Construction Workers.

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BACKGROUND

The lungs are the only vital organ in direct contact with the external environment. Its function is to provide oxygen to the blood and remove carbon dioxide. The air passes through the trachea, bronchi and bronchioles and then finally reaches the alveoli. The most important function of the respiratory passageways is to keep them patent to allow easy passage of the air, to and from the alveoli. The entire surface of the respiratory passage from nose to terminal bronchiole is lined with ciliated epithelium. These cilia beat continuously at a rate of 10 - 20 times per second, the power stroke is always upwards, but in nose it beats downwards. The dust particles are either swallowed or coughed to the exterior, but the smaller particles between 1 - 5 μ m settle down in the smaller bronchioles as a result of gravitational precipitation. Smaller dust particles than 1 μ m in diameter diffuses in the wall of the alveoli and adhere to alveolar fluid. Many of these particles that become entrapped in the alveoli are removed by alveolar

macrophages, and others are carried away by lymphatic drainage. 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.⁽¹⁾ Exposure to ambient particulate, air pollution is associated with increase in morbidity and mortality from respiratory and cardiovascular diseases.⁽²⁾

The occupation related lung diseases are more likely due to the deposition of dust in lungs and period of exposure, concentration and size of the airborne dust particles in the breathing zone.⁽³⁾ Respiratory diseases caused by exposure to mineral dust persist in both developed and developing countries despite substantial knowledge about means of their prevention. Exposure to mineral dust occurs in variety of circumstances. Workers subjected to exposure may be engaged in mineral extraction refinery, quarry tunnelling or construction.⁽⁴⁾ Decrease in pulmonary function has been reported in coal miners, grain and flour mill workers, cotton workers, workers exposed to tobacco dust, barley dust, talc dust and quarry workers.⁽⁵⁾ But none of the studies has reported about female workers engaged in building construction work in India.

All construction sites produce dust from concrete, silica, cement, asbestos, wood, stone, sand etc. Construction dust is classified as PM-10, i.e. particulate matter less than 10 μ m in diameter and workers inhale these airborne dust particles at

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Corresponding Author:

Niraj Kumar Yadav,

House No. 31, Sector-6,

Chiranjeev Vihar, Ghaziabad, Uttar Pradesh.

E-mail: nirajbhu965@gmail.com

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construction sites.⁽⁶⁾ Percentage of crystalline silica in construction and building materials are sand and sandstone 96-100%, calcium silicate 50-55%, aggregate concrete 30%, clay brick 15-27%, cement sheet 10-30%, demolition dust 3-4% and it is also present in cement dust also.⁽⁷⁾ Exposure to silica may cause acute and chronic silicosis, chronic bronchitis and emphysema.⁽¹⁾ Cement dust initially causes mucus hypersecretion followed by lung function impairment, chronic obstructive lung disease, restrictive lung disease, pneumoconiosis etc.^(1,8)

In occupational respiratory diseases, spirometer is one of the most important diagnostic tools which plays a significant role in the diagnosis and prognosis of these diseases and describes the effect of restriction or obstruction on lung function.⁽⁹⁾ Pulmonary function are influenced by many factors like sex, age, height, weight, environment and ethnicity.⁽¹⁰⁾ The severity of the impairment of pulmonary function has been shown to depend on years of exposure.⁽¹¹⁾

In India, the construction industry is the second largest and a fast growing sector. Transnational companies have been competing in construction industry since the mid 1990s, engaging in both large public sector infrastructure projects and private sector industrial projects.⁽¹²⁾ India's construction labour force is estimated at 30 million people, about half are women. Women account for 51% of total construction labour.⁽¹²⁾ So lots of female workers are engaged in construction sites. I found no study on female construction workers, so I took it as a duty to study their lung function.

The aim of study was to assess the effect of construction site dust exposure on lung function of female workers in construction field with comparison to their age matched female and also to see the effects of long duration exposure of dust on pulmonary function test.

MATERIALS AND METHODS

This is a descriptive comparative study and the study was undertaken in 110 healthy female worker subjects in building and construction work like masonry, mixing the concrete, plastering etc. We have collected data in construction area, where total number of workers were 500 (Male + Female). Out of them total number of females were 200 and 110 female workers fit for the study. Pulmonary function test was also carried out on age matched with 110 healthy housewives as control group of same area. Control are not doing any type of job like tailoring or in any other industry or in teaching job, just doing their household works. Age of subjects ranges from 26 years to 50 years of age and in following age groups- Group 1= 26-30 years of age, Group 2= 31-35 years of age, Group 3= 36-40 years of age, Group 4= 41-45 years of age and Group 5= 46-50 years of age. In each group, the duration of job is also taken as Group 1= 5 years of job, Group 2= 9 years

of job, Group 3= 15 years of job, Group 4= 20 years of job and Group 5= 25 years of job. In Group 1, number of case (n)= 22; Group 2, n= 20; Group 3, n= 22; Group 4, n= 24; Group 5, n= 22 and equal number of controls were taken for each subgroup.

Inclusion Criteria

Subjects willing to participate for study and working in building and construction throughout the years.

Exclusion Criteria

Subjects with clinical abnormalities of vertebral column and thoracic cage, anaemia, diabetes mellitus, hypertension, pulmonary tuberculosis and any abdominal or chest surgery would be excluded from the study.

All tests were conducted from July to September, so as to eliminate the seasonal variation on the pulmonary function test.⁽¹³⁾ The pulmonary function test was done two hours after the main meal.⁽¹⁴⁾ The pulmonary function test, Forced Vital Capacity (FVC) was recorded by simple spirometer and Peak Expiratory Flow Rate (PEFR) with the help of Wright peak flow meter. Parameter taken into account are observed FVC and PEFR, percent predicted are % FVC and % PEFR. Predicted value of FVC and PEFR was calculated only for the obtaining percent predicted FVC and percent predicted PEFR.

Subject's pulmonary status is diagnosed with restrictive impairment, based on the Forced Vital Capacity value below 80% of predictive value and diagnosis of obstructive impairment was based on a Peak Expiratory Flow Rate (PEFR) value below 75% of predictive value.⁽¹⁵⁾ The subjects with Forced Vital Capacity value below 80% and Peak Expiratory Flow Rate (PEFR) value below 75% of predictive value were labelled as subjects with combined lung impairment.⁽¹⁵⁾

Statistical Analysis

The data were entered into the computer and analysed by using the Statistical Package for Social Sciences (SPSS) version 10.0 programs for Windows. Unpaired student's t-test, the means and SD was calculated. The significance value was achieved at $p < 0.05$.

RESULTS

The anthropometric data for the study of female workers at building and construction site is represented in Table 1. The female construction workers were matched for age, height and weight with housewives as control. For the purpose of analysis of data, the results are tabulated according to different age group along with duration of exposure of dust at building construction site. All lung function parameters were presented and compared in mean value and 'p' value.

Group	Exposed/ Non-Exposed	Age (In Years)	Height (cm)	Weight (Kg)
Group-1 26-30 years of age n= 22	Female construction workers	Mean= 28.1 SD $\pm$ 1.24	Mean= 152.2 SD $\pm$ 2.76	Mean= 50.5 SD $\pm$ 2.03
	Housewife (control)	Mean= 27.8 SD $\pm$ 1.45 P value > 0.05	Mean= 154.1 SD $\pm$ 2.99 P value > 0.05	Mean= 55.6 SD $\pm$ 1.55 P value > 0.05
Group-2 31-35 years of age	Female construction workers	Mean= 32.2 SD $\pm$ 1.38	Mean= 152.6 SD $\pm$ 2.29	Mean= 53.4 SD $\pm$ 1.98

n=20	Housewife (control)	Mean=33.0 SD $\pm$ 1.51 P value > 0.05	Mean=154 SD $\pm$ 1.6 P value > 0.05	Mean=54.7 SD $\pm$ 1.9 P value > 0.05
Group-3 36-40 years of age n=22	Female construction workers	Mean=37.6 SD $\pm$ 1.63	Mean=154.0 SD $\pm$ 2.16	Mean=54.0 SD $\pm$ 2.04
	Housewife (control)	Mean=37.5 SD $\pm$ 1.5 P value > 0.05	Mean=152.8 SD $\pm$ 1.86 P value > 0.05	Mean=58.2 SD $\pm$ 1.91 P value > 0.05
Group-4 41-45 years of age n=24	Female construction workers	Mean=42.7 SD $\pm$ 1.28	Mean=151.0 SD $\pm$ 2.07	Mean=51.1 SD $\pm$ 3.65
	Housewife (control)	Mean=43.4 SD $\pm$ 1.28 P value > 0.05	Mean=151.3 SD $\pm$ 1.85 P value > 0.05	Mean=62.2 SD $\pm$ 3.10 P value > 0.05
Group-5 46-50 years of age n=22	Female construction workers	Mean=48.0 SD $\pm$ 1.77	Mean=152.8 SD $\pm$ 3.18	Mean=51.7 SD $\pm$ 2.31
	Housewife (control)	Mean=48.2 SD $\pm$ 1.45 P value > 0.05	Mean=152.5 SD $\pm$ 2.50 P value > 0.05	Mean=62.2 SD $\pm$ 3.15 P value > 0.05

Table 1. Anthropometric Data for the Study of Female Workers at Building and Construction Site Compared with Control

Values are mean SD. *Unpaired 't' test; not significant (P > 0.05); S, significant (P < 0.01)

Table 2 shows the comparison of lung function parameter, Forced Vital Capacity in different groups in female construction workers compared with their matched control group (housewife). In Group 1 and 2, FVC in female construction workers are lower than the control, but there was no significant difference in both FVC and % FVC. In Group 3 significant decrease in FVC and no significant difference in % FVC and in Group 4 and 5 statistically highly

significant decrease in FVC and % FVC is seen. In Group 4 and 5, the % FVC is 78.25% and 74.5% (below 80%) i.e. suggestive of restrictive type of lung disorder present in female building and construction workers with more than 15 years of duration of work. Observed FVC in all the groups are less than their predictive value and much lower in female construction workers.

		FVC (mL) Female Construction Worker	FVC (mL) Control	% FVC Female Construction Worker	% FVC Control
Group-1 5 years n= 22	Mean SD t = p value	2333 $\pm$ 225.76 0.83 >0.05	2416 $\pm$ 199.14	92.8 $\pm$ 9.26 0.144 >0.05	93.4 $\pm$ 8.3
Group-2 9 years n= 20	Mean SD t = p value	2201 $\pm$ 223.71 1.67 >0.05	2357 $\pm$ 80.66	89.4 $\pm$ 8.46 1.58 >0.05	94.8 $\pm$ 3.3
Group-3 15 years n= 22	Mean SD t = p value	2026 $\pm$ 158.32 3.89 <0.05	2293 $\pm$ 58.5	85.9 $\pm$ 7.46 3.53 =0.05	96.1 $\pm$ 1.57
Group 4 20 years n= 24	Mean SD t = p value	1731 $\pm$ 212.69 5.81 <0.001	2234 $\pm$ 127.55	78.25 $\pm$ 9.3 4.74 <0.05	93.1 $\pm$ 4.46
Group 5 25 years n= 22	Mean SD t = p value	1583 $\pm$ 237.29 6.28 <0.001	2178 $\pm$ 122.6	74.5 $\pm$ 9.99 5.59 <0.001	92.8 $\pm$ 6.17

Table 2. Forced Vital Capacity, % FVC in all groups Compared with their Matched Controls

Values are mean SD. *Unpaired 't' test; not significant (P > 0.05); significant (P < 0.05); highly significant (P < 0.001).

Graph showing Comparison of % Force Vital Capacity

Table 3 shows the comparison of pulmonary function parameter- Peak Expiratory Flow Rate, observed value, predicted value and % PEFR in different groups in female

Group/ Duration of Job		PEFR (in ml/sec)		% PEFR	
		Female Construction Worker	Control	Female Construction Worker	Control
Group-1 5 years n= 22	Mean SD t = p value	387 ±39.25 0.12 >0.05	410 ±37.6	83.5 ±8.24 0.5 >0.05	85.3 ±8.46
Group-2 9 years n= 20	Mean SD t = p value	390 ±57.35 0.45 >0.05	428 ±56.75	84.5 ±11.9 1.32 >0.05	86.2 ±11.63
Group-3 15 years n= 22	Mean SD t = p value	336 ±38.8 1.87 >0.05	397 ±13.45	72.8 ±9.5 1.33 <0.05	86.7 ±2.23
Group-4 20 years n= 24	Mean SD t = p value	285 ±40.36 2.51 <0.05	331 ±34.82	66.6 ±12.3 2.42 <0.05	79 ±7.89
Group-5 25 years n=22	Mean SD t = p value	251 ±46.7 2.06 <0.05	300 ±38.1	58.5 ±9.2 3.18 <0.05	69.3 ±5.28

Table 3. Comparison of PEFR, % PEFR in all groups Compared with their Matched Controls

Values are mean SD. *Unpaired 't' test; not significant ($P > 0.05$); significant ($P < 0.05$); Highly significant ($P < 0.001$).

Graph showing Comparison of % PEFR

building and construction workers compared with their matched control group. In all the groups, the observed PEFR and % PEFR in female construction workers were less than the control. In Group 1, 2 and 3, there was no significant decrease in observed PEFR and in Group 4 and 5 significant decreases in observed PEFR. In Group 3, 4 and 5 statistically significant decrease were seen in % PEFR. In Group 3, 4 and 5, % PEFR is 72.8%, 66.6% and 58.8% in female construction workers (below 75% of predictive value) suggestive of obstructive type of lung disorder occurring after 9 years of exposure and becomes worse after more years of exposure. But in control group, 5% PEFR (69.3%) is also below 75% of predictive value meaning as age advances PEFR may decrease due to other causes. In all the groups observed, PEFR is less than predicted PEFR value.

DISCUSSION

Occupational respiratory diseases are usually caused by extended exposure to irritating or toxic substances that may cause acute or chronic respiratory ailments.⁽¹⁶⁾ Work-related disorders are the major cause for complaints and disability in worker population. The main problem encountered in the environment is the respirable dust ($< 10 \mu\text{m}$). When fine dust enters the respiratory system, the human body considers it to be foreign material, which the body should be defended against. Exposure to ambient particulate air pollution is associated with increase in morbidity and mortality from respiratory and cardiovascular diseases. Individuals working in dusty environment face the risk of inhaling particulate materials that may lead to adverse respiratory effects. All construction sites generate high level of dust typically from concrete, silica, asbestos and cement, wood, stone, sand and the workers are exposed to this airborne dust. Dust and cement particles which are inhaled are lodged in the lung and

causes lung irritation, mucus hypersecretion initially followed by lung function impairment, lung inflammation, chronic obstructive lung disease, restrictive lung disease, pneumoconiosis and so on.^[1,8,14]

In my study, the pulmonary function tests show significant decrease in observed FVC in Group 3, 4 and 5, % FVC in Group 4 and 5, PEFR in Group 4 and 5, % PEFR shows significant decrease in Group 3, 4 and 5 of female construction workers. FVC and PEFR are lower than the predictive value in all the groups. After 9 years of cement dust exposure, obstructive type of lung impairment was seen and after 15 years of exposure, development of restrictive type of lung impairment was observed. There were chances of development of both type of lung function impairment. My reports are supported by various studies conducted from time to time by other researchers.

In a study by S. Smilee Johnney, pulmonary function parameters like FVC, FEV₁, % FEV₁/ FVC, PEFR and FEF_{25-75%} was adversely affected in construction workers and caused an obstructive pattern of lung function impairment.⁽¹⁷⁾ L. Christine Oliver and his colleagues studied the lung function of workers in highway construction work and found that FEV₁ in these workers are lower than the predicted value and are at increased risk for asthma.⁽¹⁸⁾

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.⁽¹⁹⁾

Bagatin et al analysed the influence of exposure time to silica on pulmonary function of stone quarry workers and found that the FVC, FEV₁, % FEV₁/ 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.⁽²⁰⁾

Chia KS and his co-workers in their study showed that small airway obstruction is seen in the absence of radiological evidence.⁽²¹⁾ 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 lung capacities. They found out that the exposed workers had reduced FVC, FEV₁ and FEF (25-75%).⁽²²⁾

Al-Neaimi along with his colleagues observed that pulmonary functions like FVC, FEV₁, FEV₁/ FVC and PEFR were significantly reduced in the cement factory workers in a rapidly developing country.⁽²³⁾ In study of Sultan Ayoub Meo et al found a duration response effect and shows that long-term exposure to cement dust prominently decreased the pulmonary function. Cement factory workers with duration of exposure greater than 10 years showed a significant reduction in FVC, FEV₁, PEF and MVV relative to their matched controls.⁽²⁴⁾

The dust that are floating in their vicinity due to various construction activity enter into their respiratory pathway through nose and mouth leading to chronic respiratory disease and the reduction of lung capacities.^(25,26)

Mathur ML reported a decreased PEFR in the workers exposed to silica in comparison to healthy adults.⁽²⁷⁾ The workers in the construction site and sweeping environment adversely affect their pulmonary function parameters like

FVC, FEV₁, FEV₁/ FVC%, PEFR and FEF resulting in the obstructive pattern of lung function impairment, which is associated with the years of exposure and airborne dust in the work site.⁽²⁸⁾

In a study of El Badari and Saeed, a significant reduction in FVC, FEV₁ and PEFR in cement dust exposed workers compared to control was reported.⁽¹¹⁾

Mark Purde et al found that impaired lung functions, which may be obstructive or restrictive are associated with dust exposure in the construction workers.⁽⁸⁾

CONCLUSION

The present study concluded that in female workers at construction sites, pulmonary function parameters like FVC, % FVC, PEFR and % PEFR are negatively affected due to airborne particulate material. In the female construction workers, obstructive type of lung diseases develop early, then long duration of work at construction site develops restrictive type of lung diseases. This concluded that building material dust damages the lungs. So, we recommend that workers should learn to use protective facemasks at construction sites and use other measures to reduce dust flow into the environment like spraying water to settle down the dust and reduce the lung disease burden in the community.

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