Research Article

A comparative study of lung function among sawmills workers in central India

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ABSTRACT

Background: Many of the studies have put forth the hypothesis that sawdust deteriorates lung function, increases the incidence and prevalence of diseases of the respiratory system, and can predispose to cancer and deaths. Deterioration of lung function can be tested by pulmonary function tests. Several studies have shown respiratory disorders in sawmill workers, including the reduction of pulmonary function tests, but there is a paucity of such studies in Central India; hence, in this study, we tried to study comparative lung function among sawmill workers. **Objective:** The objective of this study was as follows: (i) To study the lung function of workers in sawmill industry, (ii) comparative assessment of lung function with those of controls, and (iii) to study the effect of occupational exposure to wood dust. **Materials and Methods:** The study was carried out in the sawmills in Nagpur city from September 2013 to December 2015. Sawmill workers were the study group and local government workers as comparison group. Each worker was examined in a separate room away from the workplace. Spirometry was done to assess the lung function using the UK's Compact Vitalograph. Subjects in the control group were also examined with the spirometry. The lung function values of sawmill workers compared with the control and the difference in them was assessed both numerically and statistically. **Results:** Mean of forced expiratory volume in 1 s (FEV1), forced vital capacity (FVC), forced expiratory $flow_{25-75}$, and peak expiratory flow rate was significantly decreased among sawmill workers as compared to control group ($P < 0.05$), but FEV1/FVC ratio was significantly elevated among sawmill workers ($P < 0.05$). **Conclusion:** We have concluded that sawmill workers suffered from obstructive or restrictive type of pulmonary disorder, but the predominant type was restrictive lung disease.

KEY WORDS: Wood Dust; Sawmill Workers; Spirometry; Pulmonary Function Test; Restrictive Lung Disease; Obstructive Lung Disease

INTRODUCTION

Around 2 million people are exposed to sawdusts every day[1] around the globe.

Many of the studies have put forth the hypothesis that sawdust deteriorates lung function, increases the incidence and prevalence of diseases of the respiratory system, and can predispose to cancer and deaths. Deterioration of lung function can be tested by pulmonary function tests.[1-3]

Workers in furniture manufacturing industry have shown that respiratory system symptoms increased after exposed to wood dust. Many of the earlier studies demonstrated associations between lung function (e.g., forced expiratory volume in 1 s (FEV1), forced vital capacity (FVC), and FEV1/FVC), and exposure to sawdust.[4-6]

Several studies have shown respiratory disorders and reduction of lung function values in the sawmill workers, but there is a paucity of such studies in Central India; hence, in this study, we have undertaken comparative lung function study among sawmill workers.

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Aims and Objectives

The objectives of this study were as follows:
1) To study the lung function of workers in sawmill industry
2) Comparative assessment of lung function with those of controls and
3) To study the effect of occupational exposure to wood dust.

MATERIALS AND METHODS

This was a cross-sectional study planned in the sawmills in Nagpur city in the Maharashtra state of Central India. The study duration was from September 2013 to December 2015. List of registered sawmills was obtained from the department of forest. A pilot study was carried out on 50 sawmill workers to assess the feasibility, test the pro forma, and get an idea about the prevalence of common symptoms in sawmill workers.

Cough was found to be the most common symptom among sawmill workers (69%).
- Prevalence (P) = 0.69
- Relative error (d) = 10% of P = 0.069
- Z (1−α) = 1.96 for 95% confidence interval.
- Sample size (n) of the study = $z\ (1-\alpha)^2 \times p \times (1-p) \div d^2$
  $= 3.84 \times 0.7 \times 0.3 \div 0.07^2$
  $=164.57$

Based on the prevalence of cough (70%) in the pilot study which was the most common symptom in the sawmill workers, the estimated sample size was 164.57. There were 10 large sawmills employing 60–100 workers and 50 small-scale industries employing 5–15 workers. However, for the feasibility, only large-scale industries were included in the sampling frame. Of 10 large sawmills, two were selected randomly, one of which employing 100 workers and the other 80 workers. Hundred and eighty workers in both the sawmills were included in the study.

Large homogenous group of local government workers was selected as control group. Control group was selected in such way that they are similar to sawmill workers in terms of some sociodemographic characteristics as age and sex (individual matching).

The study was approved by the institutional ethical committee. Written informed consent was obtained from each subject.

Each worker was examined in a separate room away from the workplace. Spirometry was done to assess the lung function using the UK's Compact Vitalograph.

Pulmonary parameters studied were FEV1, FVC, forced expiratory ratio (FEV1/FVC), peak expiratory flow rate (PEFR), and forced expiratory flow $(FEF)_{25–75\%}$. Spirometry performed in afternoon during resting period. This was to avoid diurnal variation and to secure cooperation of workers. Spirometer was calibrated. Subjects were explained the whole maneuver and they were asked to practice this before doing the lung function test. The test was performed with the subject sitting in the chair without using a nose clip. The test was repeated 3 times and best (max.) reading was noted.

Control group subjects were also examined with the spirometry in the same way. The lung function values of the sawmill workers were compared with the control and the difference in them was assessed both numerically and statistically.

Statistics

The results were presented as mean ± standard deviation (SD) and the data were statistically evaluated by Z test using Epi Info version 7.0.3.

RESULTS

A total of 360 subjects were enrolled in the study, 180 of which sawmill workers (study group) and other 180 local government staff (control group). Few of the important characteristics of the study group we have studied are seen in Table 1.

Sawmill workers were working 9.28 ± 1 h daily. Most frequently sawed wood species were Indian teak (*Tectona grandis*). Few of their workplaces had ventilation system. Commonly used personal protective equipments were dust mask (25.56%) and apron (11.67%). Mean age of the sawmill workers was 33.60 years with SD of 9.53 years, range 18–58 years. About 87.22% of participants were male and 12.78% of participants were female.

Lung function values for the sawmill workers and control group are presented in Table 2. Mean values of lung function of study subjects seen in Table 2 were unadjusted for height. Mean of FEV1, FVC, $FEF_{25–75}$, and PEFR was significantly decreased among the sawmill workers as oppose to control group ($P < 0.05$); however, FEV1/FVC ratio was insignificant between the two ($P > 0.05$).

Table 3 depicts mean lung function values of study subjects adjusted for height. Age, sex, height, and ethnicity were considered as confounding variables for lung function. In the present study, age and sex were matched and ethnicity was same. Hence, height was the only confounding factor affecting lung function values. Hence, to adjust for confounding variable height, we have applied linear regression analysis. After which, it showed that mean of FEV1, FVC, $FEF_{25–75}$, and PEFR was decreased significantly among the study group as compared to control group ($P < 0.05$), but FEV1/FVC values were significantly raised ($P < 0.05$).

Table 1: Distribution of the study subjects according to some characteristics

Characteristics	Sawmill workers No. (%)	Comparison group No. (%)
Age group (years)[#]		
18–27	46 (25.55)	46 (25.55)
28–37	88 (48.88)	88 (48.88)
38–47	25 (13.89)	25 (13.89)
48–57	18 (10.00)	18 (10.00)
58–67	03 (00.00)	03 (00.00)
Gender[#]		
Male	157 (87.22)	157 (87.22)
Female	23 (12.78)	23 (12.78)
Occupational training		
Yes	00 (00)	100 (100)
Marital status		
Married	157 (87.22	138 (76.67
Smoking habit		
Ex-smoker or non-smoker	120 (66.67)	147 (81.67)
Current smoker	60 (33.33)	33 (18.33)
Working duration (years)		
≤5	86 (47.78)	104 (57.78)
6–10	51 (28.33)	24 (13.33)
11–15	27 (15.00)	23 (12.78)
≥16	16 (08.89)	29 (16.11)
Personal protective device (n=180)		
Apron	21 (11.67)	09 (05.00)
Gloves	09 (05.00)	46 (25.56)
Mask	46 (25.56)	23 (12.78)
Goggles	20 (11.11)	20 (11.11)

[#]Age and gender were matched

Table 2: Mean values of lung function of the study subjects unadjusted for height

Lung function	Study group (Mean±SD)	Comparison group (Mean±SD)	*P* value
PEFR (l/min)	5.32±1.55	7.44±1.93	<0.001
FEV1 (l/min)	2.57±0.64	2.89±0.72	<0.001
FVC (l/min)	2.80±0.66	3.13±0.72	<0.001
FEV1/FVC	0.92±0.08	0.92±0.08	0.83
$FEF_{25–75}$ (l/min)	3.61±1.20	3.92±1.43	<0.05

FEV1: Forced expiratory volume in 1 s, FVC: Forced vital capacity, $FEF_{25–75}$: Forced expiratory flow, PEFR: Peak expiratory flow rate, SD: Standard deviation

Correlation between duration of work and lung function (adjusted for height) values [Table 4] shown that FEV1, FVC, FEV1/FVC, $FEF_{25–75}$, and PEFR did not have any significant relation with the duration of work (r = 0.04; P > 0.05)

Table 5 shows mean lung function values (adjusted) of the study subjects in relation to smoking habits. Smokers among the study group had significantly decreased PEFR values than smokers among comparison group (P < 0.001), but other lung function values, i.e., FEV1, FVC, $FEF_{25–75}$, and FEV1/FVC did not show any significant difference (P > 0.05). However, non-smokers among the study group had significantly decreased lung function values, i.e., PEFR, FEV1, FVC, and $FEF_{25–75}$ than the non-smokers among comparison group. FEV1/FVC did not show any significant difference (P > 0.05) among non-smokers between the two groups.

Table 3: Mean values of lung function of the study subjects adjusted for height

Lung function	Study group (Mean±SD)	Comparison group (Mean±SD)	*P* value
PEFR (l/min)	5.97±0.84	6.78±0.79	<0.001
FEV1 (l/min)	2.60±0.27	2.86±0.25	<0.001
FVC (l/min)	2.82±0.30	3.11±0.28	<0.001
FEV1/FVC	0.92±0.001	0.91±0.00	<0.001
$FEF_{25–75}$ (l/min)	3.63±1.27	3.89±0.25	<0.001

Linear regression equation for lung function variables: y=ax+b where y was value of lung function variable in lit/min, x was value of height in meters, a and b are constants. PEFR: y=10.235x−10.508, FEV1: y=3.2512x−2.6355, FVC: y=3.6347x−3.0304, FEV1/FVC: y=−0.0064x+0.9294, $FEF_{25–75}$: y=3.3036x−1.6878. FEV1: Forced expiratory volume in 1 s, FVC: Forced vital capacity, $FEF_{25–75}$: Forced expiratory flow, PEFR: Peak expiratory flow rate, SD: Standard deviation

DISCUSSION

Workers employing in sawmills are exposed to the hazard of sawdust generated during sawing operations, pulmonary effects of which have been widely reported. Lung is the target organ of the sawdust exposure and morbidity from it can be easily studied by pulmonary function tests.

Majority of the males 75 (47.77%) and females 13 (56.52%) from the study and comparison group were from the age group of 28–37 years. The finding is consistent with Sakariya *et al*.[7] who found that mean age of the sawmill workers was 36 years; Deshpande and Afshan[8] (38.1 ± 8.1 years) and Adeoye *et al*.[9] (34.53 ± 11.01 years) also found that majority of the participants were of the age of 20–39 years; Yusuff *et al*.[10] reported mean age of 35 years and 97.5% were male; Ismaila[11] found that mean age was 37 years (range 29–46); Bello and Mijinyawa[12] found that majority of the participants were belong to the age group of 25–44 years; Johnsen *et al*.[13] reported that majority workers were male (91%); Njinaka *et al*.[14] reported that 89.7% were male; Wani and Jaiswal[15] reported that all the workers were males; and Uhumwangho *et al*.[16] reported that majority were males (89.7%) in their studies, while Johnsen *et al*.[13] reported slight older mean age, i.e., 47 (SD 12) years. Among both the groups, majority of the working population were married. None of the sawmill workers were provided with occupational

Table 4: Mean lung function values (adjusted for height) of the study group in relation to the duration of work

Duration of work (years)	PEFR (Mean±SD)	FEV1 (Mean±SD)	FVC (Mean±SD)	FEV1/FVC (Mean±SD)	$FEF_{25–75}$ (Mean±SD)
≤5	5.84±0.84	2.56±0.27	2.78±0.30	0.92±0.00	3.59±0.27
6–10	6.18±0.83	2.67±0.26	2.90±0.29	0.92±0.00	3.70±0.27
11–15	6.07±0.80	2.63±0.25	2.86±0.28	0.92±0.00	3.66±0.26
≥16	5.84±0.91	2.56±0.29	2.77±0.32	0.92±0.00	3.59±0.29
R	0.04	0.04	0.04	−0.04	0.04
P value	0.9	0.9	0.9	0.9	0.9

FEV1: Forced expiratory volume in 1 s, FVC: Forced vital capacity, FEF_{25-75}: Forced expiratory flow, PEFR: Peak expiratory flow rate, SD: Standard deviation

Table 5: Mean lung function values (adjusted for height) of the study subjects in relation to smoking habits

Smoking habits	Groups	Lung function (Mean±SD)				
		PEFR	FEV1	FVC	FEV1/FVC	FEF_{25-75}
Smokers	Study group (*n*=60)	5.90±1.55	2.67±0.6	2.90±0.61	0.92±0.08	3.82±1.10
	Comparison group (*n*=32)	7.46±1.45	2.92±0.67	3.14±0.68	0.93±0.06	3.83±1.33
	P value	<0.001	0.06	0.08	0.74	0.98
Non-smokers	Study group (*n*=120)	5.02±01.48	2.57±0.64	2.75±0.66	0.917±0.83	3.50±01.24
	Comparison group (*n*=148)	7.42±2.03	2.89±0.72	3.13±0.72	0.919±0.08	03.94±01.45
	P value	<0.000	<0.000	<0.000	0.8	0.009

FEV1: Forced expiratory volume in 1 s, FVC: Forced vital capacity, FEF_{25-75}: Forced expiratory flow, PEFR: Peak expiratory flow rate, SD: Standard deviation

training as opposed to all in the control group. About 33.33% of the sawmill workers were smokers as compared to 18.33% in the control group. High prevalence of smoking in the sawmill workers was also noted by the Osman and Pala,[1] Jacobsen *et al*.,[17] Hessel *et al*.,[18] etc. Majority (47.78%) of the sawmill workers had working (exposure to sawdust) duration of ≤5 years, but contradictory findings were noted by the Osman and Pala;[1] Boskabady *et al*.[19] who found 10+ years of working exposure. In our study, we also found that mask, apron, and goggles were the common PPE worn by the workers. Osman and Pala reported similar findings.[1]

In the present study, mean lung function values of the study subjects adjusted for height showed that FEV1, FVC, $FEF_{25–75}$, and PEFR were significantly decreased among the study group versus comparison group ($P < 0.05$). FEV1/FVC values were significantly raised among the study group than the comparison group ($P < 0.05$). These findings pointed out that obstructive (decrease PEFR, FEV1, and $FEF_{25–75}$) as well as restrictive lung disease (decreased FVC) among the sawmill workers, but predominantly sawmill workers were suffering from restrictive lung disease as decrease in FVC was more than the FEV1 (raised FEV1/FVC).

Decline in FVC, FEV1, $FEF_{25–75\%}$, and PEFR among the sawmill workers could be due to the accumulation of dust particles in the air passages. These dust particles lodge in and irritate the respiratory mucosa and sets up an inflammation in the small airways of the lung. The healing of the inflammatory process by fibrosis leads to thickening of lining of airways ultimately leads to obstructive changes.[20-22]

Findings are consistent with Vyas[23] who found restrictive impairment and obstructive impairment, Rastogi *et al*.[6] found predominant restrictive pattern among sawmill workers, and Sakariya *et al*.[7] found restrictive lung disease among the sawmill workers exposed to wood dust.

However, Deshpande and Afshan[8] found only obstructive pulmonary disorders among sawmill workers.

Mean lung function values, i.e., FEV1, FVC, FEV1/FVC, $FEF_{25–75}$, and PEFR did not show any significant relation with duration of exposure ($r = 0.04$; $P > 0.05$). This is contradictory to findings by Meo[24] and Adeoye *et al*.[9] who found that reduction in lung function values with the duration of exposure to wood dust. This may be due to majority of the sawmill workers in this study were younger, had better initial lung function and most had exposure <5 years and lung function changes take years to develop. Hence, we could be able to study relationship with duration of exposure if workers had more mean duration of exposure.

In our study, non-smokers among the study group had significantly decreased lung function values, i.e., FEV1, FVC, $FEF_{25–75}$, and PEFR than non-smokers among control group ($P < 0.05$), but there was no difference for FEV1/FVC between the two groups of non-smokers ($P > 0.05$). This finding is in accord with findings by Osman and Pala[1] and. Ugheoke *et al*.[25] Smokers among sawmill workers had a significant decline of PEFR, but there was no difference for other lung function tests (FEV1, FVC, FEV1/FVC, and $FEF_{25–75}$) between the two groups. This could be due to smoking has similar effect on the respiratory tract as sawdust

and acted as confounding factor and may have masked the effect of sawdust exposure among smokers. This finding highlighted that sawdust exposure has contributed to decline in lung function among sawmill workers.

CONCLUSION

Sawmill workers suffered from obstructive or restrictive type of lung disease, but in our study, we have found predominant restrictive type of lung disease.

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