

RESEARCH ARTICLE

Influence of sawdust on peak expiratory flow rate in sawmill workers of central India working in unprotected environment and its correlation with duration of exposure

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ABSTRACT

Background: Exposure to wood-dust has long been linked with a variety of adverse health effects. **Aims and Objective:** This study was designed to investigate the effects of saw-dust on peak expiratory flow rate (PEFR) and further to reduce the possible health risks in sawmill workers by providing information on sawdust hazards. **Materials and Methods:** A total of 50 apparently healthy male sawmill workers, without using any personal protective measures, with a mean age of 33.14 ± 9.64 years with mean duration of exposure 7.92 ± 5.47 years were selected. Age, sex and anthropometrically matched 50 healthy subjects of same socio-economic status who were not exposed to wood industries with mean age of 33.92 ± 9.68 years were selected as control group. A questionnaire was used to assess respiratory symptoms. Computerized spirometer (RMS-Helios 401, Transducer No.400-666) was used to measure PEFR. The data were analyzed using STATA version 10.0, applying unpaired *t*-test, ANOVA, and Pearson's correlation coefficient. **Results:** Unpaired *t*-test showed mean PEFR values in the sawmill workers 6.44 ± 1.45 L/s were significantly lower than in controls 7.18 ± 1.15 L/s and as the duration of exposure to saw dust increases PEFR also significantly decreases in sawmill workers. It also showed negative correlation exists between PEFR and duration of exposure on correlating both factors with Pearson's test ($r = -0.6075$) with significant $P = 0.0001$. **Conclusion:** Inflammatory changes in the respiratory tracts which lead to increased airway resistance thereby bringing about the remodeling of the airway; it can elicit pulmonary inflammation via different mechanisms and is accompanied by induction of several pro-inflammatory cytokines and chemokines, microorganisms, and toxins contained in different types of wood are potentially implicated in occurrence of asthma by inducing increased bronchial responsiveness or by damaging bronchial epithelial cells. It is possible to control the levels to within safe occupational limits with a well-designed, efficient and properly used exhaust ventilation system which should be periodically maintained. Suppression of dust technical control measures such as pre-wetting and water-sprinkling should be practiced and workers should be educated about the importance of using protective devices along with encouragement for using personal protective equipment during processing and cutting of woods.

KEY WORDS: Saw-dust; Socio-economic; Peak Expiratory Flow Rate; Inflammatory Changes; Cytokines; Chemokines; Protective Devices; Pre-wetting

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INTRODUCTION

With dawn of civilization, increased population, indiscriminate industrialization, and increased automobile utilization as a mode of transport, the intensity of pollution is escalating day by day. All these factors have an effect on the respiratory health of population.^[1-3]

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The prevalence of occupational lung diseases varies from 15 to 30% in various parts of India.^[4] Early recognition of altered lung functions will be of great clinical, social and preventive significance in the industrial workers, who are persistently exposed to various air borne pollutants. Reduction in lung function is reported in cotton mill workers, coal miners, grain and flour mill workers, workers exposed to tobacco, barley and talc dusts, etc.^[5-7]

Occupational respiratory diseases are usually caused by extended exposure to irritating or toxic substances that may cause acute or chronic respiratory ailments. The occupation-related lung diseases are most likely due to the deposition of dust in the lungs and are influenced by type of dust, the period of exposure and concentration and size of airborne dust in breathing zone.

Wood dust (sawdust) is hazardous with respiratory sensitizing properties owing to its irritating properties; it may give rise to respiratory nasal and eye symptoms. In addition, saw-mill workers have been reported to show evidence of a variety of clinical manifestation including dry cough, shortness of breath, chest pain, dermatitis, conjunctivitis, occupational asthma, wheezing, febrile reaction, lung fibrosis, rhinitis, headache, allergic alveolitis, impairment of lung function, and chronic obstructive lung disease. Exposure to wood dust has long been linked with a variety of adverse health effects. Wood dust is known to be a human carcinogen based on sufficient evidence of carcinogenicity from studies in humans.^[8-11]

The occupation-related lung diseases are an important aspect of clinical medicine. Spirometry plays a significant role in the diagnosis and prognosis of these diseases and describes the effects of restriction or obstruction on lung function.

The normal peak flow rate value for adult male is 450-550 L/min and for adult female is 350-450 L/min.

In view of the fact that sawdust puts the workers in jeopardy, this study was designed to investigate the effects of saw-dust on the peak expiratory flow rate (PEFR) and further to reduce possible health risks in saw-mill workers by providing information on hazards of saw dust (wood dust).

MATERIALS AND METHODS

After approval of the protocol of project from the Institutional Ethics Committee, this study was conducted on the sawmill workers and the controls in the pulmonary function test laboratory in the Department of Physiology, Government Medical College and Hospital, Nagpur during December 2011 to December 2013.

The investigator visited various sawmills in the Nagpur city during this period and interviewed around 100 small-scale

sawmill workers. A detailed history was taken to decide whether to include them in the study or not on the basis of the exclusion criteria. All the participants were questioned with regard to smoking cigarettes, bidis, hookah and other tobacco products and chewing tobacco, ghutka or betel nut products. After written informed consent, initial interviews and clinical examination, 50 apparently healthy male sawmill workers with a mean age of 33.14 ± 9.64 years (range 19-50 years) with mean duration of exposure 7.92 ± 5.47 years (range 1-22 years) were selected. These woodworkers worked without using any personal protective measures.

In a similar way from approximately 90 interviewed subjects, finally age, sex and anthropometrically matched 50 healthy subjects of same socio-economic status^[12] who were not exposed to wood industries with mean age of 33.92 ± 9.68 years (range 19-50 years) were selected as control group. The control group was composed primarily of shopkeepers and salesmen.

Subjects who were smokers or exposed in any industry other than wood industry (cotton spinning mill workers, flour mill workers, paint industries, safai kamgars, farmers, coal mine workers, bakers, welders, petrol pump workers, and cement factory workers) and those with any known congenital or musculoskeletal defects, endocrine disorders, cardiopulmonary disorders, any systemic disease which affects the lung functions, those who had undergone chest or abdominal surgeries were excluded from the study.

Clinical Data Recording

Before starting the work, detailed information and an informed consent were explained to subjects about this research and asking them to be volunteers. Anthropometrical parameters such as age, height in cm, and weight in kg were measured. The questionnaires were completed properly by an interviewer on discussion with volunteers before undergoing the test.

Weight was measured to the nearest 0.5 kg using digital scale and,

Height was measured to the nearest 0.5 cm using stadiometer with bare foot.

Respiratory Questionnaire

A questionnaire was used to assess respiratory symptoms (cough, sputum, breathlessness, wheezing, chest tightness), occupational history (place of work, duration of work in years, daily hours of working, type of work, questions about using gloves, a mask, or ventilation during work and whether it reduced the intensity of work-related symptoms). The questions regarding respiratory and were asked at the end of the working day or weekend (weekend

for workers in Nagpur area is Wednesday) for the wood workers and only once for the control group. The questions regarding respiratory and allergic symptoms were asked in reference to the previous 24 h (e.g. "Have you had a cough during the past 24 h?"). Common risk factors such as smoking, atopy, family history of atopy, and allergic reactions were also asked about. They also stated whether they, for some reason, had quit working as a carpenter for a period of more than a year.

Pulmonary Function Test

Computerized Spiro meter (RMS-Helios 401, Transducer No. 400-666) was used to measure respiratory function tests. This is solid state electronic equipment. The subject had to respire into a sophisticated transducer which, by the means of a cable, is connected to the instrument. The transducer converts the flow of air, breathed by the subject against a frictionless rotating vane, into an electrical signal which is used to map out the relevant plots. The apparatus provides a detailed analysis of predicted and derived values.

The precise technique of performing various lung function tests in the present study was based on the operation manual of the instrument with special reference to the official statement of the American Thoracic Society (ATS) of standardization of spirometry.^[13]

The subjects were informed about the whole maneuver before performing pulmonary function test along with the importance and non-invasive nature of the tests. All PFT were carried out at a fixed time of the day to in order to minimize any diurnal variation. The apparatus was calibrated and operated within an ambient temperature range of 25-30°C.

All the subjects were made familiar with the instrument and the procedure for performing the test. The data of the subject as regards to name, age, height, weight, sex, date of performing the test, atmospheric temperature was fed to the computer prior to the study. Under all aseptic precautions, the test was performed within the subject in sitting position with using nose clips.

The test was repeated 3 times after rest, of which the best readings were considered.

Statistical Analysis

Demographic and PEFR parameter were presented as mean \pm SD.

These parameters were compared between case and control by performing unpaired *t*-test. PEFR parameter was compared with the different duration of exposure by performing one-way ANOVA test. Correlation of duration of exposure with

PEFR parameter was assessed by computing Pearson's correlation coefficient (*r*). All the tests were 2 sided. $P < 0.05$ was considered as statistical significance.^[14] Statistical software STATA version 10.0 was used for data analysis. For all the tests, a $P < 0.05$ was considered to reflect statistical significance.

RESULTS

Overall anthropometric data, age, height, and weight did not significantly differ between the study and control groups. The mean PEFR values in the sawmill workers 6.44 ± 1.45 L/s were significantly lower than in controls 7.18 ± 1.15 L/s (Table 1) and as the duration of exposure to sawdust increases PEFR also significantly decreases (Table 2). It also showed that negative correlation exists between PEFR and duration of exposure on correlating both the factors with Pearson's test ($r = -0.6075$) with $P = 0.0001$ which is significant (Table 3 and Figure 1). From this, we can make conclusion that as the duration of exposure goes on increasing, the PEFR goes on decreasing.

Table 1: Comparison of demographic and PEFR parameters in cases and controls

Parameters	Cases	Controls	P-value
Age in years	33.14 \pm 9.64	33.92 \pm 9.68	0.6873
Height in cm	167.07 \pm 8.03	168.08 \pm 7.70	0.5229
Weight in kg	61.1 \pm 7.50	62.37 \pm 6.95	0.3823
PEFR (L/S)	6.44 \pm 1.45	7.18 \pm 1.15	0.0059*

Mean \pm SD, $P > 0.05$: Not significant, * $P < 0.05$: Significant, SD: Standard deviation

Table 2: Comparison of PEFR with respect to duration of exposure

Duration of exposure (in years)	PEFR (L/s)
<5	7.46 \pm 1.31
5-10	6.15 \pm 1.31
11-15	5.53 \pm 0.59
>15	5.03 \pm 0.62
P-value (ANOVA)	<0.0001*

Mean \pm SD. * $P < 0.05$: Significant, $P > 0.05$: Not significant. SD: Standard deviation

Table 3: Correlation of duration of Exposure with PFT parameters

PFT parameters	r value [†]	P-value
PEFR	-0.6075	0.0001*

[†]Pearson $r=1$ suggest perfect correlation; 0-1 suggests that the two variables tend to increase or decrease together; 0 suggests that the two variables do not vary together at all; 0-1 suggests that one variable increases as the other decreases; -1 suggest perfect negative or inverse correlation.^[38] * $P < 0.05$: Significant, $P > 0.05$: Not significant, mean \pm SD. SD: Standard deviation

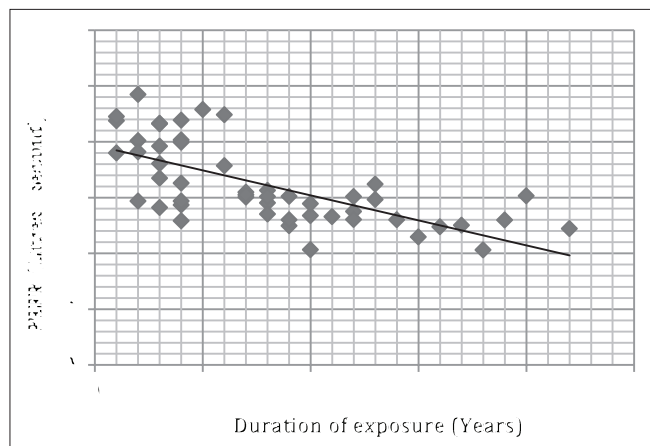


Figure 1: Scatter diagram showing correlation of duration of exposure with peak expiratory flow rate

DISCUSSION

The present study shows the decreased PEFR values in nonsmoking sawmill workers which decrease with increased duration of exposure. The other aspects of this study commendable to be bothered are that none of the workers used respiratory protective measures.

Results of our study are in agreement with the observation made by Shamssain et al.^[15] who observed pulmonary function in nonsmoking sawmill workers and reported that the exposed group had significantly lower forced expiratory indices than the control group.

The mean observed values of pulmonary function test indices in cases and controls obtained by us are slightly on the lower side than the mean values obtained by Fatusi and Erhabor,^[16] Milanowski et al.,^[17] Ige and Onadeko et al.,^[18] Okwari et al.,^[19] and Boskabady et al.^[20] who found that the sawmill workers had significant lower lung function indices (forced vital capacity [FVC], forced expiratory volume 1 (FEV1) and PEFR) compared to the control group.

Milanowski et al.,^[8] reported that woodworkers had lower FVC and FEV1 values compared to controls and also demonstrated a significant pre-shift, post-shift decline in FVC, FEV1, FEV1/FVC, and PEF among woodworkers. Our results correlate with the results observed by Milanowski et al.

Liou et al.^[21] demonstrated that the pulmonary function parameters MMF, PEFR, and FEF25% were significantly lower in the exposed workers than in controls for both smokers and non-smokers and also showed a declining trend with increasing exposure levels.

Dudhmal et al.,^[22] studied pulmonary function tests in 30 saw mill workers. They were grouped into 3 groups depending upon duration of exposure i.e. (a) <2 year, (b) 2-4 years and (c) 4-6 years. These readings were compared with controls

of same age & socio-economic status. They observed that decrease in values of FVC, FEV1 and PEFR in proportion to the duration of exposure. The present study also shows that the pulmonary functions goes on deteriorating as the duration of exposure goes on increasing.

Ihekwa et al.,^[23] showed a significant dose and duration of exposure-dependent decrease in PEFR values for sawmill workers as compared to controls, stating that they are vulnerable for developing occupational lung diseases.

In another study, Meo^[24] demonstrated that in wood workers exposed for longer periods had significantly reduced values for PEFR as compared to their matched controls.

Usman et al.^[25] observed that the PEFR value in the wood dust exposed workers was significantly reduced as compared with their matched controls. They divided the study group into 3 groups depending on the duration of exposure; from their results, it seems that the mean values of PEFR are decreasing with increasing duration of exposure. The results of our study are in harmony with those obtained by Usman et al.

The reduction in PEFR in sawmill workers might be attributed to inflammatory changes in the respiratory tracts which lead to increased airway resistance as a result of the sawdust exposure thereby bringing about the remodeling of the airway; hypertrophy of mucosal cells resulting in increased secretions of mucus and formation of mucosal plugs which cause obstruction to the exhaled air and consequently lung dysfunction.^[26,27]

The exposure to wood dust can elicit pulmonary inflammation via different mechanisms and is accompanied by induction of several proinflammatory cytokines and chemokines has been shown by Määttä et al.^[28] 2006 while elucidating the mechanisms of particle-induced inflammatory responses to fine wood dust particles.

Also, the duration of exposure-dependent decrease in the PEFR observed for workers may be due to the direct inhalation of a larger and progressively accumulating volume of sawdust particulate deposits in the lungs with associated inflammatory changes, as well as physically impeding the normal lung function.

The pulmonary function impairment that may occur after exposure to wood dust may be due to release of histamine in the bronchioles by mechanical irritation of the deposited dust in the pulmonary tract similar to the action of cotton, hemp, jute and flax dusts.^[29] Other possible causes of adverse effects of exposure to sawmill dust could be due to chemicals such as pesticides used in preserving wood.

The mechanism of pathogenesis involving the lungs in woodworkers may be due to exposure to airborne dust of

different particle sizes, concentrations and compositions, these structural components of wood are responsible for most toxic, irritant, and sensitizing effects which become a cause of impairment and worsening of lung function. In addition, wood contains many microorganisms (including fungi) and toxins, agents such as terpenes, abietic acid, and plicatic acid contained in different types of wood are, potentially, implicated in the occurrence of asthma by inducing increased bronchial responsiveness or by damaging the bronchial epithelial cells.^[30-33]

Occupational health should aim at the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations; the prevention amongst workers of departures from health caused by their working conditions; the protection of workers in their employment from risks resulting from factors adverse to health; placing and maintenance of the worker in an occupational environment adapted to his physiological and psychological equipment and to summarize: The adaptation of work to man and of each man to his job.^[34]

Preventing health impairment at occupational setting, it is important to minimize the hazards due to disease producing agent by appropriate control measures. The studies done by various authors like Laraqui Hossini *et al.*^[35] also have recommended implementation of an occupational health service and development of a means for collective and individual prevention to reduce the risk maximally. The health risk should be minimized by the mutual collaboration between health officials, woodworkers and their management. Based on the findings of the present study, the recommendations suggested are as under:^[36,37]

Although it is difficult to control dust completely, it is usually possible to control the levels to within safe occupational limits with a well-designed, efficient and properly used exhaust ventilation system which should be appropriately maintained periodically.

Periodic monitoring should be conducted to determine the concentration of wood dust.

Good housekeeping along with suppression of dust technical control measures such as pre-wetting and water sprinkling should be practiced.

The workers should be explained about possible potential health hazards of wood dust exposure and educated about the importance of using protective devices along with encouragement for using personal protective equipment (masks) during processing and cutting of woods. Preemployment medical examination and periodical medical checkups of workers by medical officer is desirable.

CONCLUSION

Inflammatory changes in the respiratory tracts which leads to increased airway resistance thereby bringing about the remodeling of the airway; it can elicit pulmonary inflammation via different mechanisms and is accompanied by induction of several pro-inflammatory cytokines and chemokines, microorganisms, and toxins contained in different types of wood are potentially implicated in occurrence of asthma by inducing increased bronchial responsiveness or by damaging bronchial epithelial cells. It is possible to control the levels to within safe occupational limits with a well-designed, efficient and properly used exhaust ventilation system which should be periodically maintained. Suppression of dust technical control measures such as pre-wetting and water-sprinkling should be practiced and workers should be educated about importance of using protective devices along with encouragement for using personal protective equipment during processing and cutting of woods.

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