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Research Article

LUNG FUNCTION INDICES IN MALE WOODWORKERS AND HEALTHY WORKERS IN CENTRAL INDIA – A COMPARATIVE STUDY

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ABSTRACT

Objectives: The objectives of the study were comparison of lung function indices in woodworkers and age, height, and weight-matched healthy workers other than woodworkers and comparison of lung function indices among woodworkers about the duration of exposure.

Methods: A comparative study of spirometry was performed on 60 male woodworkers from the Lakadganj area of Nagpur city and 60 males of age, height, and weight-matched healthy workers other than woodworkers aged from 25 to 40 years. The study was performed in the laboratory of the Physiology Department, IGGMC Nagpur from January 2012 to September 2013. The Institute Ethics Committee approved the present study and it was completed in IGGMC Nagpur. Data collection from each individual was performed using a health history questionnaire, estimation of height (cm) with roll ruler wall mounted roll ruler wall mounted stature meter, weight (kg) with weight measuring device, and well-calibrated Spirometry device Physiopac Windows-based computerized Polygraph. Age, height, weight, body mass index, and lung function indices forced vital capacity (FVC), forced expiratory volume in 1st second (FEV_1), forced expiratory flow$_{25-75\%}$ ($FEF_{25-75\%}$), FEV_1/FVC, and maximum voluntary ventilation (MVV) were included in the present study. Data analysis was performed using analysis of variance, unpaired t-test, and the Pearson correlation coefficient.

Results: Comparison of FVC, FEV_1, peak expiratory flow rate, $FEF_{25-75\%}$, FEV_1/FVC ($p<0.001$), and MVV ($p<0.05$) shows statistical significance between woodworkers and healthy workers. A negative correlation was found between FVC and all groups (Group A [−0.28], Group B [−0.33], and Group C [−0.46]). A negative correlation was found for FEV_1 in Group A (−0.08), and Group B (−0.20). A positive correlation was found for FEV_1 in Group C (0.14). $FEF_{25-75\%}$ showed a negative correlation in Group I (−0.03), and Group III (−0.19).

Conclusion: FVC, FEV_1, $FEF_{25-75\%}$, FEV_1/FVC, and MVV decreased significantly in woodworkers as compared to age, height, and weight-matched healthy workers other than saw-mill workers. There was a significant decrease in FVC, FEV_1, and $FEF_{25-75\%}$ as the duration of exposure increased but had no significant effect on FEV_1/FVC and MVV.

Keywords: Occupational lung diseases, Lung function indices, Wood dust exposure, Wood industry.

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INTRODUCTION

Wood dust is organic dust to which humans are exposed which is traditionally used as fuel and construction material as it is processed in almost all countries [1]. The wood industry (both sawmills and furniture industry) is one of the occupations where exposure to wood dust leads to lifetime lung problems long after exposure has ceased [2]. Previous studies have shown conflicting results on the association between chronic obstructive pulmonary disease and exposure to wood dust. Several studies have shown a relationship between decreased lung function and wood dust exposure [3-5]. Investigations of pulmonary function include studies of ventilation, gas transfer, blood gas transport, studies of surfactants, cytological studies, radiological studies, bronchography, these provide qualitative and quantitative measures of various aspects of broncho-pulmonary functions. Chest radiography has limited value in the diagnosis of occupation-related pulmonary impairment, as the conditions do not cause any abnormality in the chest radiograph, in the early stages [6]. Besides thorough history and clinical examination, the only sensitive technique non-time consuming, and best suited in occupational health screening is pulmonary function tests (PFTs) by spirometry. It has a role in the prognosis of occupational lung diseases which shows a description of the effect of restriction or obstruction on lung function [7].

The rationale of the present study was the assessment of lung function indices in woodworkers to create awareness among woodworkers about the hazardous effects of wood dust and the implementation of dust control measures and periodic health surveillance. Hypothesis of the present study: If there is increased exposure to wood dust, there will be decreased lung function indices among wood workers. The present study aimed to determine changes in lung function indices among woodworkers with wood dust exposure. Objectives are (1) assessment of Pulmonary Function Tests (PFTs) indices [Forced Vital Capacity (FVC), Forced Expiratory Volume in 1st second (FEV_1), Forced Expiratory Flow 25-75% ($FEF_{25-75\%}$), Forced Expiratory Volume in 1st second/Forced Vital Capacity (FEV_1/FVC) and Maximum Voluntary ventilation (MVV)] among woodworkers with wood dust exposure (2) Comparison of lung function indices among woodworkers with wood dust exposure and age, height, weight-matched healthy workers other than woodworkers (3) Comparison of lung function indices in subgroups among wood workers in relation with duration of exposure in years.

METHODS

A comparative study of spirometry was designed involving wood workers from the Lakadganj area of Nagpur city where most wood industries are located. The present study was performed in the laboratory of the Physiology Department, IGGMC Nagpur from January 2012 to September 2013. Approval of the present study was obtained from the Institute Ethics Committee and completed in IGGMC Nagpur (No. IGGMC/SS/8894/2014). The thumb rule was used for sample size determination in the postgraduate thesis as more than 30 subjects in each group. The present study consists of a total of 120 participants out of which 60 were wood workers and 60 participants were healthy workers. Data were collected from woodworkers and Age, height; weight-matched normal healthy workers included shopkeepers, salesmen, security guards, and workers from different jobs other than saw-mill workers from the same location.

Inclusion criteria

Written informed consent was taken from the included participant. The present study wood workers aged from 25 to 40 years working for 8–12 h/day for 6 days/week without using any self-protective measures with a duration of exposure of 1–15 years were included in the study. Age, height, and weight-matched normal healthy workers included shopkeepers, salesmen, security guards, and workers from different jobs other than saw-mill workers.

Exclusion criteria

Diagnosed cases of asthma, emphysema, tuberculosis, chronic bronchitis, Ischemic heart disease (IHD), malignancy, abnormalities of the thoracic cage, vertebral column, neuromuscular diseases, drug addiction, past abdominal or chest surgeries, and individuals exposed to any industries other than the wood industry having an alteration in lung functions, subjects suffering from acute respiratory symptoms were excluded from the present study.

The participants were described by a procedure that was performed for data collection.

Procedure

Age (years), height (cm), and weight (kg) were recorded and body mass index (BMI) was calculated using the formula of BMI=weight in kg/height in m^2 [8]. Equipment used in the present study was a roll ruler wall-mounted stature meter for measuring height (cm) and, a weight measuring device for weight (kg). From all participants, detailed medical history was taken with the help of a health history questionnaire [9]. *PFTs using Spirometry*: First American Thoracic Society statement on standardization of spirometry was in 1979 which was updated in 1987 and again in 1994 [10-12]. Pulmonary functions in woodworkers and age, height, and weight-matched normal healthy workers were measured with well-calibrated spirometry using Physiopac Windows-based computerized Polygraph machine Medicaid systems, Chandigarh.

After obtaining age, height, and weight participants were informed and instructed about maneuvers performed. The subject was prepared for the procedure. The well-qualified technician demonstrates the appropriate technique and follows the procedures of FVC and MVV maneuvers as below. *Procedure for recording FVC*: Correction of Posture was done with the head slightly elevated. Have the subject assume the correct posture application of the nose clip was done. Placement of the mouthpiece was done in mouth and closure of lips was done around the mouthpiece. Inhalation was complete and rapid with a pause of 1 s at TLC. Exhalation was maximal till no more expelled air while maintaining an upright posture. Repetition of maneuvers was performed (minimum three maneuvers) as per requirement. *Procedure for recording MVV:* The method of measuring MVV was as follows. Application of Nose clip was done and the participant was instructed to breathe for 12 s with possible maximal inspiration and expiration. The result was displayed on the monitor expressed as L/min. the procedure was repeated 3 times after giving the rest for 10 min [11,13,14].

The results were displayed on the monitor. The readings taken were best of three. The machine gives predicted values and observed values based on age height, and weight of the subject on maximum inspiration and expiration.

Statistical analysis

In terms of mean and standard deviation (SD) data were expressed. Unpaired t-test and analysis of variance were used to compare quantitative data. The Pearson correlation coefficient was used to correlate between different variables. Statistical significance was tested at 5% and considered statistically significant in terms of p-value with p<0.05 [15]. GraphPad Instat version 3.1 was the software used for the statistical analysis of observed values.

RESULTS

The present study was conducted on 60 male woodworkers from 25 to 40 years mean age of 31.37±4.56 years and 60 age, height, and weight matched healthy male workers from 25 to 40 years mean age of 32.43±2.81 years. Table 1 shows anthropometric parameters expressed in mean and SD. Age, height, weight, and BMI showed a non-significant statistical difference between woodworkers and healthy workers. Table 2 shows the observed values of spirometry expressed in terms of mean and SD. Comparison of FVC, FEV_1, peak expiratory flow rate (PEFR), $FEF_{25-75\%}$, FEV_1/FVC (p=0.00001), and MVV (p=0.02360) shows statistical significance between woodworkers and healthy workers.

The study group of wood workers was further divided into three subgroups Group A (n=28), Group B (n=23), and Group C (n=09), based on wood dust exposure duration of 1–5 years, 6–10 years, and 11–15 years, respectively. Table 3 shows a comparison of lung function indices in each group. Duration of wood dust exposure in subgroups was Group A (3.0±1.41 years), Group B (8.0±1.31 years), and Group C (12.78±1.39 years). FVC (p=0.0227), FEV_1 (p=0.0113), and $FEF_{25-75\%}$ (p=0.0164) showed a significant statistical difference while FEV_1/FVC and MVV showed non-significant differences. The table also explains the linear correlation of each variable of lung function indices about wood dust exposure within each group. There was a negative correlation for values of FVC in all subgroups (Group A [−0.28], Group B [−0.33], and Group C [−0.46]). A negative correlation for values of FEV_1 was shown in Group A (−0.08), and Group B (−0.20), and a positive correlation in Group C (0.14). $FEF_{25-75\%}$ showed a negative correlation in Group I (−0.03), and Group III (−0.19) and a positive correlation in Group II (0.07). FEV_1/FVC and MVV showed positive correlation in all subgroups

Table 1: Anthropometric variables in healthy workers and woodworkers

Anthropometric variables	Mean±SD		p-value
	Healthy workers (n=60)	Woodworkers (n=60)	
Age (years)	32.43±2.81	31.37±4.56	0.065
Height (cm)	163.82±2.94	164.03±2.36	0.3285
Weight (kg)	58.63±2.53	57.88±6.44	0.2013
BMI (kg/m^2)	21.86±1.08	21.5±2.19	0.1254

Test used to compare quantitative data was an unpaired *t*-test. SD: Standard deviation, BMI: Body mass index

Table 2: Observed values of lung function indices in healthy workers and woodworkers

Pulmonary function indices	Mean±SD		p-value
	Healthy workers (n=60)	Woodworkers (n=60)	
FVC (L)	3.2±0.38	2.6±0.58	0.00001*
FEV_1 (L)	2.69±0.32	1.93±0.52	0.00001*
$FEF_{25-75\%}$ (L/s)	4.54±1.06	2.61±0.95	0.00001*
FEV_1/FVC (%)	87.04±6.02	73.34±14.4	0.00001*
MVV (L/min)	81.55±32.12	71.67±20.6	0.02360*

*Represents p<0.05. Test used to compare quantitative data was an unpaired *t*-test. SD: Standard deviation, FVC: Forced vital capacity, FEV_1: Forced expiratory volume in 1^{st} s, $FEF_{25-75\%}$: Forced Expiratory $Flow_{25-75\%}$, FEV_1/FVC: Forced expiratory volume in 1^{st} s/forced vital capacity, MVV: Maximum voluntary ventilation

Table 3: Comparison of lung function indices in three subgroups (Group A, B, and C) among woodworkers based on duration of exposure in years

Subgroups among woodworkers	Group A (n=28)		Group B (n=23)		Group C (n=09)		ANOVA
	Mean±SD	r	Mean±SD	R	Mean±SD	r	
Duration of wood dust exposure (years)	3.0±1.41	–	8.0±1.31	–	12.78±1.39	–	
PFTs variables							
FVC (L)	2.78±0.55	−0.28	2.52±0.56	−0.33	2.21±0.51	−0.46	0.0227*
FEV_1 (L)	2.12±0.58	−0.08	1.82±0.33	−0.20	1.59±0.51	0.14	0.0113*
$FEF_{25-75\%}$(L/s)	2.98±1.07	−0.03	2.28±0.68	0.07	2.3±0.78	−0.19	0.0164*
FEV_1/FVC (%)	76.25±12.96	0.11	71.16±14.06	0.06	69.85±19.04	0.02	0.3396
MVV (L/min)	73.1±24.71	0.14	69.9±14.34	0.05	71.69±22.39	0.66	0.8639

*Represents level of significance (p<0.05). Test used to compare quantitative data were ANOVA. "r value" value represents the Pearson correlation coefficient.
SD=Standard Deviation, FVC: Forced vital capacity, FEV_1: Forced expiratory volume in 1st s, $FEF_{25-75\%}$: Forced expiratory flow$_{25-75\%}$, FEV_1/FVC: Forced expiratory volume in 1st s/forced vital capacity, MVV: Maximum voluntary ventilation, ANOVA: Analysis of variance

(Group A [0.11 and 0.14], Group B [0.06 and 0.05], Group C [0.02 and 0.66]), respectively.

DISCUSSION

Present study, PFT variables FVC, FEV_1, $FEF_{25-75\%}$, FEV_1/FVC, and MVV were compared between wood workers and healthy workers. FVC, FEV_1, $FEF_{25-75\%}$, FEV_1/FVC, and MVV showed a statistically significant difference between woodworkers and healthy workers. Okwari *et al*. concluded that a significant decrease (p<0.01) values of FVC, FEV_1, FEV1%, and PEFR than control subjects of timber workers were shown [16]. In Meo's study of woodworkers, a significant decrease in FVC, FEV_1, and MVV among controls with wood dust exposures longer than 8 years was shown. There were no significant differences in the value of means of FEV_1/FVC% and $FEF_{25-75\%}$ [17]. Bhat and Ramaswamy showed that FVC was significantly decreased in saw-mill workers compared to both controls and rice mill workers. Both mill workers compared to controls FEV1 were significantly reduced [18]. Mandryk *et al*. studied that a significant association between percentages of predicted lung function (FVC, FEV_1, FEV_1/FVC, $FEF_{25-75\%}$) was shown in joinery workers, saw-mill, and chip mill workers [19].

The present study includes the Pearson correlation coefficient which is used to measure the linear correlation of the duration of wood dust exposure with each PFT variable in three subgroups Group A (n=28), Group B (n=23), and Group C (n=09) based on duration of exposure 1–5 years, 6–10 years, and 11–15 years, respectively in wood workers. A negative linear correlation was shown in all three groups and values of FVC while FEV_1 showed a negative correlation in Group A, and Group B and a positive correlation in Group C. As the duration of wood dust exposure increases FVC, FEV_1 declines significantly. A decrease in FVC may be due to pathological changes in the bronchi and elastic component of the lungs resulting in lung function impairment [20]. The decline in FEV_1 may be due to increased non-specific bronchial reactivity to histamine [21]. The effect of the duration of wood dust exposure on $FEF_{25-75\%}$ was significant, and a negative correlation in Group A and Group C was present. Thus, as the duration of wood dust exposure increases $FEF_{25-75\%}$ decreases. Leaullen and Flower (1995) noted that a decrease in $FEF_{25-75\%}$ decreases flow rates. $FEF_{25-75\%}$ is indicative of small airway narrowing. It increases pulmonary flow resistance with decreased pulmonary compliance [22]. Meo, FVC, FEV_1, and MVV were significantly declined in woodworkers. These were directly proportional to the period of exposure to wood industries. Regression analysis for FVC, FEV_1, $FEF_{25-75\%}$, and MVV showed a significant negative correlation. It indicates increased duration of wood dust exposure decreased lung function parameters [17]. Bhat and Ramaswamy FVC were decreased in saw-mill workers after 5 years of exposure only. FEV_1 was reduced in sawmill and rice mill workers within 1 year which was further declined after 5 years [18]. The present study confirms the findings from other studies mentioned earlier.

Dutch hypothesis proposes that in chronic obstructive lung disease, the risk of irreversible obstruction, and chronic disease increases due to airway hyper-reactivity, resulting from an inflammatory response to an inhaled substance [23]. Present data indicating a decrease in flow rates may be attributed to airway narrowing, an increase in airway resistance, and a decrease in pulmonary compliance. The future perspective of the present study is to create awareness among woodworkers about the hazardous effects of wood dust exposure and implementation of dust control measures and clinical assessment of periodic health surveillance.

Further studies can be performed in the future to assess the specificity of individual lung function indices which may be affected by the duration of wood dust exposure. As the present study is non-funded other investigations to assess the inflammatory and other changes in the lung due to wood dust exposure can be possible if further future studies are carried out. Thus, this is the limitation of the present study.

CONCLUSION

Continuous wood dust exposure adversely affects lung function indices. FVC, FEV_1, $FEF_{25-75\%}$, FEV_1/FVC, and MVV in woodworkers reduced significantly in age, height, and weight-matched healthy workers other than woodworkers. An inverse correlation of the duration of wood dust exposure with lung function indices FVC, FEV_1, and $FEF_{25-75\%}$ was present, and the duration of wood dust exposure had no significant effect on FEV_1/FVC and MVV.

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AUTHORS CONTRIBUTIONS

Contribution of each author is as follows: Dr. Pravin Sainikrao Gowardipe: Concepts, design, literature search, data acquisition, data analysis, and manuscript preparation. Dr. Mohammad Shahid Usman: Concepts, definition of intellectual content, manuscript editing, and review. Dr. Durain Fatima: Literature search and statistical analysis.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

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