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Research Article

Effect of Occupational Wood Dust on Pulmonary Function among Woodworkers in Jimma Town, Southwest Ethiopia, A Comparative Cross Sectional Study

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Abstract

Background: Wood dust is one of the most common sources of occupational exposures in the world. Occupational exposure to wood dust has been shown to cause several respiratory disorders resulting in decreased work output and increased respiratory morbidity, such as asthma, allergic rhinitis, chronic bronchitis, and impairment of lung function. Despite its hazardous nature, there is lack of study concerning respiratory health status of wood workers in Ethiopia. The present study aimed to investigate pulmonary function status of woodworkers in Jimma town.

Method: A community based comparative cross-sectional study was conducted among 70 woodworkers and 70 non-woodworkers (shop-keeper). Pulmonary function parameters such as Forced Expiratory Volume in first second (FEV1), Forced Vital Capacity (FVC), Forced Expiratory Flow (FEF 25-75%) and Peak Expiratory Flow Rate (PEFR) were measured by digital Spirometer. A standardized questionnaire was used to assess socio-demographic variables of the study participants.

Results: A mean pulmonary function test parameters among woodworkers were FVC (3.19 ± 0.64) L, FEV1 (2.70 ± 0.66) L, PEFR (5.22 ± 1.63) L/s and FEF25-75% (3.97 ± 1.29) L/s while among non-exposed group FVC was (3.69 ± 0.57) L, FEV1 (3.23 ± 0.44) L, PEFR (6.01 ± 1.59) L/s and FEF25-75% (4.54 ± 0.99) L/s with significance statistical difference of p-value less than 0.01 among groups. Pulmonary function tests were negatively correlated with body mass index and duration of wood dust exposure among woodworkers.

Conclusion: A significant reduction in mean pulmonary function parameters were observed among woodworkers in compared to non-exposed groups. Efforts should be exerted to mitigate the untoward effect of wood dust and preventive measures, and awareness creation about wood dust-related respiratory problems should be considered.

Keywords: *Occupational Effect; Pulmonary Function Tests; Wood Dust; Woodworker*

Introduction

Among the various types of organic dust to which humans are exposed; Wood dust is one of the most common occupational exposures, with millions of workers exposed worldwide. Wood is harvested in almost all countries for its traditional use for fuel and construction material, and it is found to contribute for respiratory problems among exposed workers globally [1]. Approximately 3.6 million workers in the European Union are exposed to wood dust [2].

Wood dust is made as a by-product of wood processing during cutting or shaping of wood materials where its components have a property of sensitizing and irritating the mucous membrane [3].

Most wood dust particle enters the human body through the respiratory system and causes direct toxicity via lytic damage to alveolar, tracheal and bronchial epithelial cells induce the release of pro-inflammatory mediators from macrophages to express and induce the release of inflammatory mediators in human epithelial cell line and modulate the expression of cytokines and chemokine as pathophysiology for different identified respiratory diseases both carcinogenic and non-malignant (allergic rhinitis, chronic bronchitis, occupational asthma, and impairment of pulmonary function parameters) [4-13].

The most likely causes of occupation-related lung diseases are due to the deposition of dust in the lungs; this affected by the types of dust, the period of exposure, the concentration and size of airborne dust in the breathing zone [11].

Despite, Jimma, the ancient city of king Aba Jifar is a pioneer of wood and wood products, there is limited studies conducted in the area to assess the occupational burden of wood working on respiratory function [14]. Thus, the present study aimed to investigate pulmonary function status of woodworkers in Jimma town.

Materials and Methods

Study populations

The study was conducted in Jimma town, located in the Oromia region, about 354 km distance to southwest direction, from the capital city of Oromia and Ethiopia, Finfine. According to Jimma town entrepreneur and food security agency of 2017/2018 report, there are 300 small-scale wood processing industries in the town involving 1012 male and 548 female woodworkers. The data was collected from April 5 to May 3, 2018 G.C among sampled woodworkers and non-exposed group (shopkeepers) for comparison by employing comparative cross-sectional study design.

Selection criteria

The exposed group of woodworkers who worked for more than one year and no history of smoking, and non-exposed group (shopkeepers) who had never worked in woodwork or other wood related industry were recruited in matching with year of service, age, sex and BMI. All individuals of both groups (exposed and non-exposed) with history of pulmonary tuberculosis, heart failure, common cold, history of smoking, any acute illness were excluded from the study as it affects the results of dynamic pulmonary function tests measured by spirometer.

Sample size determination

The sample size was determined by using analytical study sample size calculation formula by taking two-sided confidence level of 95%, a power of 80% with a double proportion formula [15]. Finally, the total sample of 140 (70 exposed group and 70 unexposed group) was endorsed after considering design effect and 5% non-response rate.

Sampling technique

Multistage sampling technique was used to select the exposed study participants. First, five kebeles were selected by simple random sampling from the total 17 kebeles of the town. Then, by considering equal weight allocation of the sample to each selected kebeles; 14 small-scale wood work enterprises were selected by simple random sampling from the total 300 small-scale wood processing industries distributed in kebeles of the town. From each enterprise, one eligible respondent was selected by simple random sampling method. The comparison group of shopkeepers was selected by convenience sampling technique matching with age, sex, duration of service and BMI to selected woodworkers.

Data collection tools and procedures

Pulmonary function test

Pulmonary function parameters (FEV1, FVC, FEF 25 - 75% and PEFR) were measured by digital spirometer (Contec™ SP10 Spirometer, China) at the ambient room temperature of 20 - 30ºC. A minimum of 3 and a maximum of 8 acceptable and repeatable forced expiratory maneuvers were done by using spirometer at sitting and upright position according to ATS/ERS 2005 criteria [16]. Other variables were assessed by an interviewer-administered questionnaire.

Data processing and analysis

Data was checked for completeness and entered to Epidata version 3.1 and finally exported to IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: USA for further analysis. Descriptive statistics were used to summarize the finding and statistical analysis of the difference between proportions was done by the use of the chi-square test. The mean respiratory test scores of the exposed and non-exposed group were compared using independent sample t-test and Pearson's correlation coefficient was used to quantify the degree of linear relationship between pulmonary function tests and some predictor variables.

Result

Baseline characteristics

The mean age of the woodworkers was 27.86 ± 7.88 years and the control groups was 26.49 ± 5.378 years. The mean height of woodworkers and non-woodworkers was (169.90 ± 6.084) cm and (170.66 ± 5.941) cm; the mean weight was 59.89 ± 5.77 kg and 59.99 ± 5.59 kg among woodworkers and control group respectively as listed in table 1.

Pulmonary function tests

The overall mean values of pulmonary function parameters for exposed and their matched non exposed group were analyzed. The

Characteristics	Woodworkers (n = 70)	Non-woodworkers (n = 70)	P-value
Age, mean ± SD	27.86 ± 7.886	26.49 ± 5.378	0.209
Height, mean ± SD	169.74 ± 5.93	170.80 ± 5.958	0.95
Weight, mean ± SD	59.89 ± 5.77	59.99 ± 5.599	0.917
BMI, mean ± SD	20.7871 ± 1.70	20.548 ± 1.22	0.344
Duration of service, mean ± SD	7.20 ± 5.45	7.45 ± 4.40	0.04*

Table 1: *Baseline characteristics of woodworkers and control group in Jimma town, Southwest Ethiopia, 2018 G.C.*
P < .05 significant, BMI: Body Mass Index; SD: Standard Deviation.
**Test statistics by independent sample t-test.*

values of FVC, FEV1, PEFR and FEF 25% - 75% were significantly decreased in woodworkers as compared to control group. The mean of FVC was 3.195L and 3.6961 among woodworkers and control group respectively. There was significant (P < 0.001) decrease in the mean FVC among woodworkers in comparison to non-woodworkers. The mean FEV1 among woodworkers was 2.703L and 3.237L among non-wood workers with statistically significant difference (P < 0.001). The mean of FEV1/FVC (%) was 85.0813 and 86.857 among wood workers and control groups respectively. But the difference was not statically significant (P = 0.222). The mean of PEFR among woodworkers was 5.2283 L/sec and showed statistically significant difference (P = 0.005) in compared to non-woodworkers 6.009 L/sec. There was also significant reduction in mean FEF 25 - 75% among exposed woodworkers (3.979 L/sec) in comparison to control group (4.5431 L/sec) as detailed in table 2.

Parameters	Groups	Mean	Std. Deviation	Std. Error Mean	p-value*
FVC (L)	Woodworkers	3.1956	0.64608	0.07722	P < 0.001*
	Non-woodworkers	3.6961	0.5773	0.06901	
FEV1 (L)	Woodworkers	2.7030	0.66022	0.07891	P < 0.001*
	Non-woodworkers	3.2371	0.4978	0.05950	
FEV1/FVC%	Woodworkers	85.0813	14.28614	1.70752	0.222
	Non-woodworkers	86.8577	10.41434	1.24475	
PEFR (L/S)	Woodworkers	5.2283	1.63788	0.19576	0.005*
	Non-woodworkers	6.0097	1.59886	0.19110	
FEF 25 - 75% (L/S)	Woodworkers	3.9791	1.29986	0.15536	0.006*
	Non-wood workers	4.5431	0.99753	0.11923	

Table 2: *Comparison of pulmonary function parameters among woodworkers and non-woodworkers in Jimma Town, Southwest Ethiopia, 2018. Data are expressed as mean value of certain spirometric parameter with standard deviation. *Tested by independent-samples t-test , P < .05 significant P > .05, Non-significant, L/S: Litter Per Second, FVC: Forced Vital Capacity; FEV1: Forced Expiratory Volume in the First Second; FEV1/FVC%: Percentage of FEV1 to FVC; PEFR-Peak Expiratory Flow Rate; FEF 25 - 75%-Forced Expiratory flow at 25% to 75% of FVC.*

Relation of pulmonary function tests to predictor variables among woodworkers

The Pearson's correlation was applied to describe the correlation of pulmonary function parameters with predictor variables like age, body mass index, height, and duration of service of woodworkers. A statistically significant ($p < 0.05$) negative correlation was found between the pulmonary function parameters and age of exposed woodworkers [age and FVC ($r = -0.36$, $p = 0.02$], [age and FEV1 ($r = -0.35$, $p = .003$], [age and PEFR ($r = -0.36$, $p = .002$], [age and FEF25-75% ($r = -.286$, $p = .016$]. There was also observed negative correlation of pulmonary function parameters with duration of work experience in years of exposed group with statistical significance of p-value < 0.05) [work experience in years and FVC ($r = -0.501$, $P < .001$], [work experience and FEV1 ($r = -0.402$, $p = .001$], [work experience and PEFR ($r = -0.340$, $p = .004$], [work experience and FEF25-75% ($r = -.337$, $p = .004$]. But a significant positive correlation was also discerned between weight of woodworkers and PFPs [weight in kg and FVC ($r = .275$, $p = 0.021$], [weight and FEV1 ($r = 0.236$, $p = .049$]. No significant correlation ($p > .05$) was found between BMI and the values of lung function parameters (Table 3).

Test parameters	Duration of wood work employment	Age	Height	Weight	BMI
FVC (L)	r = -0.501, P<.001	r = -0.36, p = 0.02	r = 0.16, p = .17	r = .275, p = 0.021	r = -.178, p = 0.141
FEV1(L)	r = -0.402, p = .001	r = -0.35, p = .003	r = 0.19, p = .116	r = 0.236, p = .049	r = -0.108, p = .372
FEV1/FVC%	r = 0.008, p = .949	r = 0.10, p = .399	r = .004, p = .97	r = -0.07, p = .540	r = -0.087, p = .472
PEFR (L/S)	r = -0.340, p = .004	r = -0.36, p = .002	r = 0.091, p = .456	r = -0.09, p = .450	r = -0.038, p = .756
FEF 25% - 75% (L/S)	r = -.337, p = .004	r = -.286, p = .016	r = .244, p = .042	r = .194, p = .108	r = -.056, p = .643

Table 3: *Correlation of pulmonary function parameters with predictor variables among woodworkers in Jimma town, Southwest, Ethiopia, 2018. P < .05 significant, p > .05, non-significant.*
r = Pearson Correlation Coefficient.

Discussion

Occupational exposure to wood dust has been shown to cause several respiratory disorders such as allergic rhinitis, chronic bronchitis, asthma, sino-nasal adenocarcinoma, and impairment of lung function [11]. In the present study, it was showed that woodworkers experience a significant decrease in the mean FVC, FEV1, PEFR and FEF 25% - 75% in comparison to non-woodworkers. The decrease in pulmonary function parameters among woodworkers is attributed to the inhaled high wood dust concentration in the air and it reflects the number of woodworkers having lung function impairments due to inflammation of lung parenchyma, mucosal hyperplasia, bronchial smooth muscle cell hypertrophy and decreased lung connective tissue that result in reduction of adequate filling of the lungs, increased air way resistance and decreased air flow rate [4,8].

The result of the present study was comparable to the study done in Ghana by Isaac E Ennin., *et al.* who reported that pulmonary function parameters among woodworkers were significantly reduced in comparison to non-woodworkers [FVC (3.46 ± 0.08L vs 3.63 ± 0.07L), FEV1 (2.58 ± 0.07L vs 2.90 ± 0.06L), FEV1% (73.12 ± 2.03 vs 79.13 ± 1.01 and FEF 25-75% (2.52 ± 0.11 vs 3.00 ± 0.10)] (17). Another similar study was done by Asia and Atram in India who revealed a significant decline in pulmonary test parameters among woodworkers in compared to non- woodworkers [FVC (3.57 ± 0.11 vs 3.04 ± 0.20), (FEV1/FVC% (86.3 ± 5.96 vs 67.4 ± 10.8), PEFR (6.36 ± 0.172 vs 5.71 ± 0.15)] [18]. In general, the finding of the present study was in harmony with previous studies [19-29] to reveal the reduction of PFPs in exposed woodworkers in relative to matched control group.

In the present study, pulmonary function tests were negatively correlated with age, body mass index, and duration of wood dust exposure. The other possible explanation to this is; as age, BMI and duration of service advances by one unit, the PFTs were reduced by specific r value. The correlation of PFPs with those variables among woodworkers observed in the present study was also in agreement with the study of Mamta Mohan., *et al* [30]. The correlation of PFPs with duration of the service was also supported by other studies and concluded the lung function indices decreased with their length of service or duration of exposure [27,28,31].

However, the study of Baran., *et al*. revealed that the duration of wood dust exposure would not related to pulmonary functional parameters [11].

Conclusion

In conclusion a significant reduction in mean pulmonary function test values (FVC, FEV1, PEFR and FEF25-75%) were observed among woodworkers as compared to non-exposed groups. Pulmonary function tests were negatively correlated with body mass index and duration of wood dust exposure whereas height and weight were positively correlated with pulmonary function test parameters. Thus, the present finding was very crucial for evidence based decision making as it will help occupational health policy makers' for planning of preventive and control measures. With this finding,we emphasis the need for health and safety regulation in the workplace.

Competing Interests

The authors declare that they have no competing interests.

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Author's Contribution

DF designed and conducted the main research. TG involved in data interpretation, analysis, manuscript revision and write up. WR involved in data analysis and interpretation and write up. All authors reviewed and approved the final manuscript EM involved in preparing the study designed data analysis and manuscript drafting.

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