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Wood dust effects on carpenters pulmonary function test parameters: a comparative study

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Abstract

Background Few studies have investigated the effects of wood dust on carpenters, who are frequently exposed to this hazardous material. This study aimed to determine the effects of wood dust exposure on carpenters pulmonary function test (PFT) parameters.

Methods This comparative cross-sectional community-based study included 130 participants; a group of carpenters and a matched cohort. Standard techniques were used to measure each participant's force vital capacity (FVC), force expiratory volume in one second (FEV1), FEV1/FVC ratio, and peak expiratory flow rate (PEFR). Statistical tests were employed to investigate different variables. A P value of <0.05 is considered significant.

Results Carpenters had a mean age of 51.6 ± 19.9 years, whereas the matched cohort had a mean age of 49.8 ± 13.9 years. Approximately 23 (35.4%) carpenters experienced respiratory problems. Carpenters had significantly lower FEV1, FVC, FEV1/FVC%, and PEFR values than the matched cohort ($P < 0.001$). Additionally, the association between the carpenters duration of exposure to wood dust and their PFT values showed a significant statistical difference ($P < 0.05$). Likewise, the correlation between the duration of exposure to wood dust and their PFT values was significant (<0.001).

Conclusions Wood Dust's Effects on carpenters' respiratory systems are worth further discussion. Awareness campaigns should be undertaken to educate carpenters about lung health and preventative measures.

Keywords Wood dust, Carpenters, Pulmonary function tests, PEFR, FVC, FEV1, PFT

Background

A healthy workforce is vital for long-term social and economic growth at the global, national, and local levels [1]. It is well established that professions requiring continuous contact with various materials and chemicals have a variety of health consequences for workers, and carpenters are no exception. Although these compounds have been shown to harm many body systems, the lungs are especially vulnerable to airborne risks generated by exposure to wood dust from sawmills, the furniture industry, joineries, and carpentry [2].

The most common way of exposure to wood dust is through inhalation, which can cause major health concerns such as small-cell lung cancer, leukaemia, and a range of pulmonary symptoms [3–5]. Furthermore, wood dust exposure is linked to an increased risk of asthma [6, 7]. Carpentry work was linked to a high incidence of respiratory problems, particularly after exposure to irritating chemicals [8]. Several studies have described the

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prevalence of respiratory symptoms, such as catarrh, chest pain, cough, nasal irritation, wheezing, sputum production, runny nose, oral irritation, shortness of breath, and rapid breathing, in apparently healthy workers exposed to wood dust [9–11]. Nonrespiratory symptoms (skin and eye irritation) are also prevalent [9].

Previous studies have investigated the impact of wood dust on the respiratory health of carpenters. Some of these studies reported significant reductions in PFTs among carpenters and sawmill workers [8, 10–14]. Furthermore, woodworkers often have lower FEV1 [11, 12, 15], FVC [12, 15], and maximum voluntary ventilation (MVV) [12] than matched controls. Additionally, Mamta Mohan et al. reported that carpenters' mean PEFR was lower than that of controls and that persistent exposure to wood dust harmed their respiratory condition [2]. Okwari et al. demonstrated that wood workers exposed to wood dust exhibited a restrictive pattern of ventilatory function impairment (9). Restrictive lung diseases have also been recorded among wood dust workers [8].

Many studies have investigated the relationship between the duration of wood dust exposure and the reduction in PFT parameters, result in conflicting findings. Saad Hussain et al. surveyed sawmill workers and reported that lung damage was not strongly correlated with exposure length [10]. Furthermore, no dose-response association was discovered between the level of exposure to airborne dust or microorganisms and changes in FEV1 and FVC in any factory, whereas those exposed to the highest dust concentrations tended to demonstrate the largest decreases in FEV1 and FVC [15]. On the other hand, Sultan Ather et al. reported a significant reduction in the PEFR in wood workers exposed to wood dust for more than 8 years compared with their matched controls [16], whereas Meo SA et al. reported that lung impairment increased with increasing duration of exposure in the wood industry. The study concluded that lung function is decreased in woodworkers, and stratification of the findings revealed a dose-response effect of years of wood dust exposure on lung function [12]. Additionally, Okwari et al. reported that the lung function indices of woodworkers decreased with increasing length of service, implying that chronic exposure to wood dust compromises lung function [9].

This study was carried out to determine the effects of wood dust exposure on PFT parameters in a cohort of Sudanese carpenters who worked in a setting without respiratory safeguards.

Methods

Study design, duration and setting

This comparative cross-sectional community-based study was performed between May and June 2022 at the Omdurman crafts (Alhiraaf) market in Sudan. The Omdurman Crafts Market is the largest handcrafted wood furniture market in Khartoum Province. Carpentry is a male-dominated field in Sudan, and no women work in this industry. There are approximately 23 carpenter wood shops in this area, and they operate in an environment without wood dust control ventilation or respiratory protection devices. The average working period while they are exposed to wood dust is nine hours per day.

Study population and eligibility criteria

For comparison, the study included woodworkers as well as age, sex, and height-matched group of university employees (directors, accountants, secretaries and teaching staff) who had no prior occupational exposure to respiratory dangers. Sudanese adults over 18 years of age with carpentry as their primary profession for at least one year were included. Smokers (past or present), those receiving chronic therapy for any disease; those with known cardiopulmonary disease (ex. Asthma, heart failure, etc.); those with other chronic diseases (diabetes, hypertension, renal diseases, etc.); or those with any contraindication for lung function tests (e.g., history of eye, chest, or abdominal surgery; haemoptysis; current respiratory infection; and history of pneumothorax, emboli, or aneurysms) were excluded.

Sample size determination

Approximately 84 carpenters were working in these wood shops. Sixteen workers smoked, and three had significant health conditions; therefore, they were disqualified. A remainder of 65 carpenters volunteered to participate in the study.

Data collection tool and procedure

The participants were surveyed by a single investigator (to reduce interinvestigator variability) via a structured questionnaire that included questions about personal data, work duration, and history of respiratory problems and smoking. (Questionnaire attached as Supplementary file 1) All the subjects underwent a general physical examination. Height and weight were measured, and body mass index (BMI) was computed as weight (kg) divided by height (m2).

Pulmonary function tests were performed via an electronic digital spirometer (pocket microspirometer, VIASYS Healthcare GmbH, D-97204 Hoechberg, Germany) under the American Thoracic Society and European Respiratory Society (ATS/ERS) recommendations [17]. In a sitting position, the subjects were told to inspire maximally and rapidly with a pause of ≤ 2 s at total lung capacity (TLC) and then to expire forcefully with maximal effort into the mouthpiece of the spirometer until no more air could be expelled while remaining upright. The

Table 1 Demographic characteristics of the study participants

Character		Carpenter		Matched cohort	
		Number	Percentage	Number	Percentage
Mean age/year		51.6 ± 19.9		49.8 ± 13.9	
BMI/ kg/m2		21.9 ± 3.96		22.6 ± 3.2	
Duration of work/ year	1–10	20	30.76	20	30.76
	11–20	18	27.69	18	27.69
	21–30	13	20	13	20
	More than 30	14	21.53	14	21.53
Current respiratory symptoms	Sneezing	11	16.9		
	Cough	8	12.3		
	Shortness of breath	3	4.6	**Asymptomatic**	
	Chest pain	1	1.5		

Table 2 Difference between PFT values of the study participants

PFTs parameters	Carpenters (means ± SD)	Matched cohort (means ± SD)	*P*-value
FEV1 (L)	2.50 ± 0.61	3.07 ± 0.27	< 0.001*
FVC (L)	2.92 ± 0.62	3.39 ± 0.27	< 0.001*
FEV1/FVC%	86.00 ± 6.37	90.58 ± 1.24	< 0.001*
PEFR (l/min)	467.39 ± 37.63	476.71 ± 29.58	< 0.001*

* Difference in independent t test

- FEV1 = forced expiratory volume in one second (FVC1), FVC = forced vital capacity, FEV1/FVC = ratio, and

PEFR = peak expiratory flow rate

- SD = standard deviation, L = litre, %= percentage, min = minute

forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV1/FVC ratio, and peak expiratory flow rate (PEFR) were measured. Each subject received three readings, with the best of the three recorded. The PFT findings of the study participants were compared (for age, sex, and height) to the PFT values in a matched cohort of university employees (directors, accountants, secretaries and teaching staff) who had no prior occupational exposure to respiratory dangers. Because the study participants were originally from different ethnic backgrounds, it was very difficult to control for the ethnicity between the two groups.

Statistical analysis

The data were examined with SPSS software version 25. The distribution of the data was assessed via the Kolmogorov‒Smirnov and Shapiro‒Wilk tests. Continuous variables are reported as the means and standard deviations (SDs), whereas categorical data are presented as frequencies and percentages. The statistical variation across variables was assessed via an independent t-test and ANOVA. To determine the correlations between carpenters duration of exposure to wood dust and their PFT findings, correlation (Spearman) analysis was applied. A P value < 0.05 was considered significant.

Results

The mean age of the carpenters was 51.6 ± 19.9 years, while that of the matched cohort was 49.8 ± 13.9 years. The carpenters had a mean BMI of 21.9 ± 3.96 kg/m2, whereas the matched cohort had a mean BMI of 22.6 ± 3.2 kg/m2. Table 1 displays the duration of work for carpenters, which indicates the period of exposure to wood dust as well as the percentages of current respiratory problems.

Compared with the matched cohort, the carpenters had significantly poorer FEV1, FVC, FEV1/FVC%, and PEFR values. Table 2.

Compared with those in the matched group, the values of the PFT parameters in carpenters are substantially lower as their exposure to wood dust is higher. Table 3.

A significant correlation founded between duration of wood dust exposure and PFT values. Table 4.

Discussion

This study investigated the impact of wood dust exposure on pulmonary function in a group of Sudanese carpenters. The majority of our study participants reported no respiratory problems at work. However, sneezing was the most prevalent respiratory symptom, followed by coughing. Similarly, woodworkers in Nigeria who were exposed to wood dust experienced coughing, chest pain, nasal irritation, sputum production, shortness of breath, wheezing, and rapid breathing [9, 11]. Additionally, Allergic and nonrespiratory symptoms such as nasal congestion, redness or itching of the eyes, runny nose, mouth irritation, and eye irritation have all been documented in workers exposed to wood dust and chemicals in the furniture sector [9, 10, 13]. Furthermore, Awoke et al. reported chronic respiratory symptoms among workers in medium-scale woodwork factories documented a significant rate of chronic respiratory problems [18]. Also, Hessel et al. reported a significant incidence of cough and wheezing attacks among woodworkers, indicating a link between fresh wood dust exposure and the development of asthma symptoms, cough, bronchitis, acute and

Table 3 Difference between PFT values of the study participants and the duration of exposure to wood dust

Years of exposure	Number (%)	FEV1(L)		P values		FVC (L)		P values	
		Matched (means ± SD)	Carpenters (means ± SD)	ρ®	ρ¥	Matched (means ± SD)	Carpenters (means ± SD)	ρ®	ρ¥
1–10	20 (30.76)	3.59 ± 0.18	3.14 ± 0.51	0.433	**< 0.001***	595 ± 0.16	3.52 ± 0.45	0.550	**< 0.001***
11–20	18 (27.69)	3.15 ± 0.21	2.52 ± 0.45	**< 0.001***		3.47 ± 0.22	2.88 ± 0.53	**< 0.001***	
21–30	13 (20)	2.96 ± 0.19	2.25 ± 0.4	**0.002**		3.29 ± 0.19	2.63 ± 0.42	**0.003***	
>30	14 (21.53)	2.78 ± 0.23	2.0 ± 0.33	**< 0.001***		3.11 ± 0.23	2.41 ± 0.4	**< 0.001***	
Years of Exposure	**Number (%)**	**FEV1/FVC (%)**		**Pvalues**		**PEFR (l/min)**		**Pvalues**	
		Matched (means ± SD)	**Carpenters (means ± SD)**	ρ®	**ρ¥**	**Matched (means ± SD)**	**Carpenters (means ± SD)**	ρ®	**ρ¥**
1–10	20 (30.76)	91.00 ± 1.19	89.20 ± 5.85	**0.031***	**0.044***	499.1 ± 17.3	498 ± 17.24	0.544	**< 0.001***
11–20	18 (27.69)	91.00 ± 0.73	87.5 ± 5.0	**0.004***		485.7 ± 23.3	476.9 ± 29.4	**0.005***	
21–30	13 (20)	90.00 ± 0.49	85.55 ± 8.3	**0.01***		464.5 ± 20.5	451.5 ± 26.4	0.107	
>30	14 (21.53)	89.38 ± 0.89	82.9 ± 5.4	**< 0.001***		444.6 ± 25.3	426.1 ± 33.3	**< 0.001***	

* ρ®= Difference between the exposed and matched groups according to independent t test

* ρ¥= Difference between years of exposure among carpenters according to ANOVA

- FEV1 = forced expiratory volume in one second (FVC1), FVC = forced vital capacity, FEV1/FVC = ratio, and PEFR = peak expiratory flow rate

- SD = standard deviation, L = litre, %= percentage, min = minute

- Years of employee in the matched group was adjusted to match for the years of experience in the exposed group

Table 4 Correlations between the duration of wood dust exposure and PFT values

	Pulmonary function test parameter	Correlation	Values
Duration of exposure	FEV1(L)	ρ coefficient	⁻-0.696
		P Value	**< 0.001***
	FVC(L)	ρ coefficient	⁻0.673
		P Value	**< 0.001***
	FEV1/FVC ratio (%)	ρ coefficient	⁻-0.326
		P Value	0.008*
	PEFR(L/min)	ρ coefficient	-0.707
		P Value	**< 0.001***

*Spearman correlation

- FEV1 = forced expiratory volume in one second (FVC1), FVC = forced vital capacity, FEV1/FVC = ratio, and PEFR = peak expiratory flow rate

- SD = standard deviation, L = litre, %= percentage, min = minute

chronic lung function impairment, and rhinoconjunctivitis [19].

On the other hand, Jacobsen et al. reported that type 1 allergies are unlikely to be a substantial source of wood dust-induced asthma and concurrent exposure to microbes and terpenes most likely contributes to the inherent risk of wood dust exposure in the fresh wood sector [20]. Bioaerosols are biological particles comprising organic and inorganic dust and biological fractions floating in the air, including viruses, bacteria, endotoxins, fungi, and secondary metabolites of fungi, as well as plant and animal particles. When these elements enter the respiratory tract, they can cause irritating, toxic, allergic, carcinogenic, or fibrotic reactions, as well as respiratory and skin problems [21–23]. As a result, bioaerosols are considered extremely hazardous in the workplace since they include a wide range of airborne microorganisms and their inhalation has been linked to some inflammatory and allergic illnesses in exposed workers [24]. Furthermore, in sawmill workers in India, Candida sp. was identified in their sputum as related to respiratory symptoms and sputum eosinophilia [25].

In our study, the carpenters had lower mean values for FVC, FEV1, FEV1/FVC%, and PRFR than did their matched cohort. These findings are consistent with those published in a Nigerian study, which revealed that timber workers had considerably lower FVC, FEV1, FEV1%, and PEFR values than control individuals did. The timber worker's lung function indices decreased as their service time increased and they demonstrated a restricted pattern of impaired lung function [9]. Additionally, Meo et al. in a study of woodworkers, reported a substantial decrease in PFT findings in woodworkers, and this impairment increased with exposure duration, demonstrating a dose-response effect of years of wood dust exposure [12]. Another study conducted in Saudi Arabia reported that the PEFR was considerably lower among woodworkers who had been exposed to wood dust for more than 8 years compared to a matched group [16]. One of the processes by which wood dust causes toxicity in the lungs is oxidative stress. The entry of wood dust particles into airways may cause oxidative stress and inflammatory reactions, resulting in increased airway resistance [26–28]. This may result in a decrease in PFT values as well as an obstructive or restrictive pattern in persons exposed to wood dust. In contrast, some studies documented that wood dust exposure does not have such a detrimental effect on lung function [29, 30]. In our results, the association between the duration of exposure to wood dust and decreased lung function values is generated after cautious control for the confounding variables. However, the age-related changes to the respiratory system that tend to reduce participant's reserve may still be inflicted. This apparent contradiction between the results of prior research may be attributed to changes in the worker's age, exposure time, wood dust concentrations, the type of wood and processing method, applied technology, geographical location, the mill size or climatic conditions, and ventilation system [29–32].

Strengths, limitations and future prospects

This is the first study in Sudan to examine the effects of wood dust on carpenter PFT parameters. Furthermore, the presence of a comparison group strengthens the conclusion drawn from this study. However, our study has several drawbacks. First, the small sample size may restrict the generalizability of the study's findings. Second, the recollection and answer bias inherent in such surveys limit the drawn conclusion. Third, although we maximize our efforts to adjust for the effect of age, gender, and height on PFT values through the involvement of a comparison group, the generated findings seemed to be partially balanced for age and not for ethnicity. Thus, a more advanced statistical analysis with age as a covariate, or more adjustments for a national or international reference set (e.g., Global Lung Function Initiative) that attempts to control for age and ethnicity when producing a percent predicted value will increase the credibility of the results. To reduce the detrimental effects of wood dust on carpenter respiratory health, we recommended that individuals receive preemployment instructions on the risks and wear personal protection equipment at the workplace. In addition, regular medical check-ups and good ventilation in the workplace should be considered.

Conclusions

Wood Dust Effects on Carpenters Respiratory Systems worth More Discussions. Awareness campaigns should be undertaken to educate carpenters about lung health issues and preventative measures that can be taken.

Abbreviations

PFT	Pulmonary function test
FVC	Forced vital capacity
FEV1	Forced expiratory volume at one second
PEFR	Peak Expiratory flow rate
MVV	Maximum Voluntary Ventilation
GLI	Global Lung Function Initiative

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12890-025-03535-x.

Supplementary Material 1: Supplementary file; the study questionnaire

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Author contributions

N. M. E. obtained study approval; contributed to the study design, data collection and analysis; and wrote the first draft.I. A. A. contributed to the study design, data collection, analysis, and interpretation, and supervised the research.M. A. M. contributed to the study design, data collection, analysis and interpretation, and wrote the final draft.I. A. A. contributed to the study design, data collection, analysis and interpretation and wrote the final draft.N. A. A. contributed to the data analysis and interpretation, reviewed the scientific content, and drafted and edited the manuscript.O. A. M. reviewed the scientific content and co-supervised the research.All the authors read and approved the final version of the manuscript.

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Data availability

The data generated in this study are available from the corresponding author upon reasonable request and a completed Materials Transfer Agreement, with the exception of materials containing personally identifiable information.

Declarations

Ethics approval and consent to participate

All procedures involving human participants in this study were carried out following ethical standards established and approved by the research committee of the Faculty of Medicine at the National Ribat University, Khartoum, Sudan, as well as the 1964 Declaration of Helsinki and its subsequent amendments or comparable ethical standards. Following a clear and basic description of the research technique and study aims, each participant provided written informed consent. The participants were promised that the data obtained would be kept strictly confidential and used exclusively for research purposes.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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