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EVALUATION OF CARDIOVASCULAR AND PULMONARY STRESSES OF CARPENTERS IN RELATION TO THEIR PROFESSIONAL EXPERIENCE

Mousumi Chatterjee, Surajit Sau, Hiranmoy Mahata and Prakash C. Dhara
Ergonomics and Sports Physiology Division,
Department of Human Physiology with Community Health,
Vidyasagar University, Midnapore-721102, West Bengal

ABSTRACT ■ A large number of workers are involved in carpentry work in India. The present study was aimed to evaluate the prevalence of pulmonary disorders and cardiovascular stress of carpenters. The study was conducted on 60 carpenters having the age range of 18 to 60 years. They were selected from several carpenters' workshops in different districts of West Bengal, India. The subjects were divided into two groups according to their professional experience, viz., Gr.-A (work experience < 15 years) and Gr.-B (work experience > 15 years). Different pulmonary function parameters, viz, forced vital capacity (FVC), forced expiratory volume in 1st second (FEV1), forced expiratory flow between 25-75% (FEF25-75), peak expiratory flow (PEF), maximum voluntary ventilation (MVV) were determined using a digital spirometer for analyzing the pulmonary efficiency and the prevalence of chronic obstructive pulmonary disease (COPD) among the carpenters. The resting and working heart rates were measured by a heart rate monitor. The cardiovascular stress index was determined from the pulse rate by the standardized formula. From the results it was noted that the FVC, FEV1 and MVV were significantly lower among the carpenters having work experience more than 15 years than that of the workers with less work experience. The occurrence of moderate and severe degree of COPD was greater in higher experience group than that in lower experience group. The mean working heart rate and cardiovascular stress index was significantly greater ($p < 0.001$) in higher experience group in comparison to lower experience group. It was also revealed that the age of the carpenters had a positive correlation with CSI and negative correlation with PFT parameters. It was concluded that the carpenters having greater work experience were suffering from cardiovascular and pulmonary stresses to a greater extent than that lower experience group which might be related to age and long term exposure to dust.

Key words: Carpenter, pulmonary function tests, cardiovascular stress, work experience

INTRODUCTION

Carpentry is one of the most versatile construction occupations. A large number of people in our country are engaged in carpentry tasks. According to census 2001 total no of population engaged in carpentry task was 18, 85,319 among them18,62,689 were male and 22,630 were female. Carpenters while carrying out their professional jobs are exposed to wood dust and may have various types of pulmonary and cardiovascular diseases. Various research works had been carried out on this job and on other profession

like, construction, mining, leather and various other hazardous industries where dust is problem for the health of the workers.. Wood dust is created when machines are used to cut or shape wood materials. Industries that have a high risk of wood-dust exposure include sawmills, dimension mills, furniture industries, cabinet makers, and carpenters. Negative health effects have been associated with professions that shape, cut, or work wood.

Different groups of researchers have observed reduced pulmonary function parameters in wood workers as compared to those in general population. Pramanik and Chaudhury (2013) found that 58% of carpenters were suffering from work related respiratory symptoms. Coughing and wheezing were the most common symptoms. All respiratory symptoms were higher in smoker than nonsmoker carpenters. The result of pulmonary function test (PFT) indicated that there was a significant decrease in lungs volume viz., forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) while ratio of FEV1/FVC was normal. Pulmonary flow rate including peck expiratory flow rate (PEFR) and Maximal mid expiratory flow rate (FEV 25-75%) also reduced significantly. Vyas (2012) carried out the pulmonary function tests and showed that there was a significant variation in pulmonary function tests in workers of different dust industries. The decrease in FVC and MVV indicates a restrictive impairment whereas decrease in FEV1, FEF25-75, and PEFR indicates an obstructive impairment. Boskabady et al. (2010) observed prevalence of work-related respiratory symptoms, like, cough (34.4%), sputum (33.3%) and wheezing (15.15%) among carpenters. All respiratory symptoms were significantly higher in carpenters than in controls ($p<0.001$). Most allergic symptoms, viz, itchy eyes and sneezing were also significantly greater among the carpenters than in the control group ($p<0.05$). Most respiratory and allergic symptoms in the carpenters increased during work compared to rest period. Mohan et al. (2013) depicted that the mean PEFR of carpenters exposed to wood dust was less than that of the control subjects in each sub group of age, height, weight and BSA and these results were statistically significant. Bergdahl et al. (2004) observed that occupational exposure among construction workers increases mortality due to chronic obstructive pulmonary disease, even among never-smokers. Hnizdo and Vallyathan (2003) reviewed the epidemiological and pathological evidence relevant to the development of COPD in silica dust exposed workers. A growing number of literatures have confirmed that endotoxin is the main mediator obstructive lung diseases (Khan et al. 2007; , Rylander et al., 1985; Niven et al.,1996).

The effect of wood dust exposure on cardiovascular parameters was not much found in the literature. Tanko et al (2011) studied pulse rate and blood pressure on the exposure of wood dust among the carpenters. He noted that that the pulse rate was not significantly varied between carpenters and non-carpenters. As regard to the pulse rate there was no significant change in the carpenters when compared with the non-carpenters. In relation to the systolic, diastolic and mean arterial blood pressure, there was a significant increase ($p<0.05$) in the carpenters when compared with the non-carpenters.

The pulmonary function parameters and the work related cardiovascular stress may be varied as a function of the duration of exposure to wood dust. The duration of exposure may be proportional to the work experience. In view of a dearth in information on this issue, it was necessary to carry out the present re-

search as a detailed study on effects of work experience on the above parameters. Efforts have been made to assess the pulmonary efficiency and prevalence of chronic obstructive pulmonary disease (COPD) as well as cardiovascular stresses among the carpenters in relation to their work experience.

MATERIAL AND METHOD:

Site and subjects

The study was conducted on 60 male carpenters in the age group of 18 to 60 years, selected from East and West Midnapore distracts of West Bengal, India. The subjects were divided into two groups according to their professional experience viz., Gr.-A (duration of work experience <15 years); Gr.-B (duration of work experience >15 years).

PULMONARY FUNCTION TESTS

Different pulmonary function parameters, e.g., forced vital capacity (FVC), forced expiratory volume in 1st second (FEV1), forced expiratory flow between 25-75% (FEF25-75), peak expiratory flow (PEF),maximum voluntary ventilation(MVV) had been measured by digital spirometer (Micro Medical Ltd., England). The subject was asked to hold the instrument by two hands. They were asked to fit the mouthpiece of the spirometer in their mouth and instructed to seal their lips around the mouthpiece. To avoid nasal expiration, nose clip was used. They were instructed to take the breath as much as possible followed by blow out of air into mouthpiece as hard and as fast as possible till they could not breath out any more air. After complete the whole procedure, the above parameters were recorded as shown on its display screen. Three trials for each subject were given and the highest value was recorded.

The definition of COPD was based on Global Initiative for Chronic Obstructive Lung Disease (GOLD) working group criteria (Pauwels et al. 2001) of forced expiratory volume in 1 second (FEV1) / forced vital capacity (FVC) less than 70 percent and FEV1 less than 80 percent predicted. The criteria followed for categorization of the severity of COPD were based upon the GOLD spirometric criteria for COPD severity (Table 1)

To assess the severity of COPD, lung function test value was predicted from the standard prediction equation of normal male subjects. The following equation was used for predicted FEV_1 :

Predicted FEV_1= -0.028 * A+0.047 * H-3.737,

Where, A =Age in years, and H = Height in Centimetre

COPD% = Predicted FEV_1 / FEV_1 *100

The criteria followed for categorization of the severity of COPD were based upon the GOLD spirometric criteria for COPD severity as given in Table 1.

Table 1: GOLD Spirometric Criteria for COPD Severity

Stage	Severity	FEV1/FVC	FEV1	Symptoms
I.	Mild COPD	FEV1/FVC < 0.7	FEV1 >/= 80% predicted	At this stage, the patient is probably unaware that lung function is starting to decline
II.	Moderate COPD	FEV1/FVC < 0.7	50% </= FEV1 < 80% predicted	Symptoms during this stage progress, with shortness of breathe developing upon exertion.
III.	Severe COPD	FEV1/FVC < 0.7	30% </= FEV1 < 50% predicted	Shortness of breath becomes worse at this stage and COPD exacerbations are common.
IV.	Very Severe COPD	FEV1/FVC < 0.7	FEV1 < 30% predicted or FEV1 < 50% predicted with chronic respiratory failure	Quality of life at this stage is gravely impaired. COPD exacerbations can be life threatening.

CARDIOVASCULAR STRESS INDEX

The resting and the working heart rate were recorded by a heart rate monitor. The resting heart rate was measured under sitting condition 30 minutes before the beginning of the professional work. The working heart rates of the carpenters was recorded every one hour interval for the entire working period and the mean value was expressed as working heart rate. The cardiovascular stress index (CSI) was determined by the following formula (Trites et al 1993).

$$CSI = \frac{100\ (\text{Heart rate during work} - \text{Heart rate during rest})}{\text{Heart rate maximum} - \text{Heart rate at rest}}$$

Where, Heart rate max = 220 – Age (years).

ANTHROPOMETRIC DATA:

The height of the workers was taken by an anthropometer using standard landmark definition and weight was measured by a portable human weighing machine with an accuracy of 0.5 kg. The body mass index (BMI) of the subjects was determined by the following formula: BMI= weight (Kg) / height ^{2} (meter).

ANALYSIS OF DATA

To test the significance of difference of physical and physiological parameters between two groups, the Student's t- test was performed by using Origin Pro software.

RESULTS:

The carpenters were divided into two groups according to their work experience. The recorded data were compared between two

groups. The subjects having their professional experience in carpentry tasks less than 15 years were designated as Group A and the subjects with professional experience of more than 15 years were treated as Group B. The age, height, weight, BMI and work experience of two groups have been presented in table 2.

Table -2 : Mean ± SD of physical parameters of the carpenters

Parameter	group- A [Working experience <15 years] (n= 30)	group- B [Working experience >15 years] (n= 30)
Age(years)	20.50±2.64	45.30±10.95**
Height(cm)	158.47±7.91	163.89±6. 51*
Weight(Kg)	48.25±7.55	54.80±7. 35*
BMI(Kg/m^2)	19.20±2.49	20.43±2.66
Work experience (year)	3.80±2.27	28.90±7.46**

*p<0.01, **p<0.001

Table 3: Mean ± SD of heart rate and Cardiovascular Stress Index (CSI) of the carpenters

Parameters	group- A [Work experience <15 years] (n= 30)	group- B [Work experience >15 years] (n= 30)
Resting HR (beats/min)	75.10±3.09	75.13±2.94
Mean Working HR (beats/min)	106.01±6.12	118.23±7.80*
CSI	24.85±7.75	34.02±7.86*

*p<0.001

Table 2 portrayed a significant variation of various parameters such as age, height, weight, and work experience of carpenters. The BMI of lower experience group was 19.20 Kg/m^2 and in higher experience group it was 20.43 Kg/m^2 respectively. However there was no significant difference in BMI between the subjects of two experience groups.

The resting and mean working heart rate and CSI of the carpenters were compared in Table 3. The results depicted that the mean working heart rate of the carpenters was significantly greater ($p<0.001$) in higher experience group than that lower experience group. The higher experience group had a significantly greater ($p<0.001$) cardiovascular stress index (CSI) in comparison to lower experience group.

Different PFT parameters, viz., FVC, FEV1, FEF 25%-75%, PEF and MVV index of carpenters having two levels of experience have been shown in Table 4 .

It was noted that that some of the pulmonary function test parameters such as FVC, FEV1 and MVV were significantly lower ($p<0.05$ or less) among the carpenters of higher experience group than that of lower

Table 4: Comparison of Different parameters of Pulmonary Function Test (PFT) between two groups of carpenters

PFT Parameters	**group- A [Work experience <15 years] (n= 30)**	**group- B [Work experience >15 years] (n= 30)**
FVC (Lit)	2.75±0.58	2.23±0.72*
FEV1 (Lit)	2.53±0.60	1.96±0.72*
FEF 25%-75% (Lit/Sec)	2.62±0.32	2.53±0.58
PEF (Lit/Sec)	4.77±1.42	4.11±1.63
MVV index (Lit/min)	80.58±0.55	77.45±0.73**

w. r. t group –A *p<0.01, **p<0.001

Table 5: Severity of COPD in workers (percentage) according to their work experience

Severity of COPD		group- A [Work experience <15 years] (n= 30)	group- B [Work experience >15 years] (n= 30)
		Percentage	Percentage
Total percentage of COPD		10.00	16.67
Classification	I. Mild COPD	10.00	0.00
	II. Moderate COPD	0.00	10.00
	III. Severe COPD	0.00	6.66
	IV. Very Severe COPD	0.00	0.00

experience group. Other PFT parameters, e.g., FEF and PEF25%-75% also showed a lower values, although non-significantly, in higher experienced group than that of lower experience group.

Table 5 illustrated the severity of COPD of two groups of carpenter. It was observed from results that the occurrence of COPD was higher (16.67%) among the carpenter having higher work experience in comparison to the lower experience group. From the GOLD classification of COPD it was observed that in lower experience group 10% of the carpenters were suffering from mild COPD. On the other hand the carpenters of higher experience group had higher degree of COPD. It was noted that 10% of them were suffering from moderate COPD and 6.66% of them had severe COPD. No evidence of very severe COPD was observed in any of the groups of carpenters.

Table 6: has been shown to represent the correlation coefficients of CSI and different parameter of PFT like FVC, FEV1, FEF 25%-75%, PEF, MVV index with age of workers. From results it was found that the PFT parameters were negatively correlated with age. However the index of cardiovascular stress was positive correlated with age. According to table CSI was increased with increasing with age. The efficiency of pulmonary function was decreased with age.

Table-6: Correlation coefficient of CSI and different PFT parameters with age of carpenter (n=60)

	CSI	FVC (Lit)	FEV1 (Lit)	FEF 25%-75% (Lit/Sec)	PEF (Lit/Sec)	MVV index (Lit/min)
r- value	0.744	-0.339	-0.358	-0.554	-0.208	-0.383
Significance level	P<0.001	P<0.01	P<0.01	P<0.001	NS	P<0.01

DISCUSSION

The results revealed that the carpenters of higher experience group had greater working heart rate and cardiovascular stress index (CSI) in comparison to lower experience group. This might be due to couple of reasons. The carpenters of higher experience group had higher range of age and greater duration of exposure to wood dust during work. Tanko et al (2011) suggested that exposure to particulate matter evolved from wood dust might be associated with increased heart rate among older individuals, especially those with obesity and the metabolic syndrome. Exposure to particulate matter air pollution contributes to acute cardiovascular morbidity and mortality (Brook *et al*., 2004) and exposure to elevated level of particulate matter over the long term can reduce life expectancy by a few years. Ahmed et al (2011) also showed that there was a significant difference in FVC ($p<0.001$) and FEV1 ($p<0.01$) between control group and marble workers. Iyawe and Ebomiyi (2005) who observed that sawdust exposure ultimately results in airway remodeling and lung dysfunction, and that this lead to increased airway resistance which manifested as lower peak flow rate value in the woodworkers compared to the control.

In the present study pulmonary function parameters such as FVC, FEV1, FEF25-75, PEF and MVV were lesser in higher experience group than the lower experience group. It might be due to their higher age and spending longer duration of time in the working area having wood dust. In addition to that the carpenters would not use any mask during work, which might facilitate the entry of dust into the respiratory passage. This is consistent with the work of Ige and Onadeko (2000) who observed a reduced lung function parameters in woodworkers when compared with the general population. Decrease in FVC and FEV1 indicates an obstructive pattern of lung disease. Decrease in FEF indicates a pathology involving the larger airways due to wooden dust. Studies have shown that wooden dust induces histamine release or immunological reaction antigen-antibody reaction as mechanism of wooden dust disease (Rastogi et al ,1989 ; Rongo et al ,2002)

Reduced respiratory capacity may induce the occurrence of COPD. In the present study the carpenters of higher experience group had moderate to severe degree of COPD. Similar findings were also obtained by Boskabady et al. (2010). Friesen (2007) suggested that a lifetime of exposure to wood dust was associated with a doubling in the risk of hospitalisations for COPD. Other workers (McLean, 2007) also noted both obstructive and restrictive pulmonary effects due to exposure to wood dust. A dose–response relationship between cumulative wood dust exposure and percent annual decrease in FEV_1 was suggested for female workers. Further, for females, a positive trend between wood dust exposure and the cumulative incidence proportion of FEV_1/FVC <70% was

suggested (Jacobsen, 2008). It appeared from the present study that inhalation of dust is an important cause of lung disease in India (Jindal et al.,2001). The probable cause for the decrease in pulmonary function was the accumulation in peri-bronchial lymphoid and connective tissues along with varying degrees of wall thickening and remodelling in terminal and respiratory bronchioles arising from each pathway. Bronchiolar walls with marked thickening contained moderate to heavy amounts of carbon and mineral dust and wall thickening was associated with increase in collagen and interstitial inflammatory cells including dust laden macrophages (Pinkerton et al.,200)

A potent cause for higher values of cardiovascular stress and lower values of PFT parameters in higher experience group might be the higher age range of the carpenters in this group. It was evident from the fact that the cardiovascular stress had a significant positive association with the age of the workers (Table 6). Thus it indicated that the CSI became increased with the advancement of age of the carpenters. Different factors are responsible for this kind of occurrence. Aging alters cardiovascular system both structurally and physiologically. The cumulative effects of multiple changes contribute to reduced cardiac reserve and efficiency even in absence of diseases(Morgan,1993). With increasing age the ability of cardiac muscle is decreased and also decreased the working ability of man. Decrease in muscle mass of the heart and contractility of the myocardium produce decline in stroke volume, cardiac output and maximal work capacity. (Smith, 1984). For this reason heart muscle of an aged person have to pump more forcefully for fulfilling the demand of body than that of a person of comparatively young age for fulfilling the same demand of the body. On the other hand the PFT parameters were significantly lower in higher experience group. Most of the PFT parameters were significantly and negatively correlated with age. Therefore, it appeared that PFT parameters were also influenced with the advancement of age in addition to the duration of exposure to the wood dust.

CONCLUSION

It may be concluded that the carpenters had impaired lung functions due to performing wood works. The workers, who were more experienced in wood working, had declined pulmonary efficiency and increased cardiovascular stress, which might be related to their advanced age and greater exposure to the dust in the working areas.

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