RESEARCH ARTICLE

Evaluation of Pulmonary Capacity and Prevalence of Pulmonary Dysfunctions of Bell Metal Workers in Relation to their work Experience and Smoking Habit

Naba Kumar Das[1], Hiranmoy Mahata[2], Prakash Chandra Dhara[3*]

[1]Research Scholar, Department of Human Physiology with Community Health, Vidyasagar University, Midnapur, West Bengal, India

[2]Research Scholar, Department of Human Physiology with Community Health, Vidyasagar University, Midnapur, West Bengal, India

[3]Professor, Ergonomics and Sports Physiology Laboratory, Department of Human Physiology with Community Health, Vidyasagar University, Midnapur, West Bengal, India

[*]**Address for Correspondence:** Dr. Prakash Chandra Dhara, Professor, Ergonomics and Sports Physiology Laboratory, Department of Human Physiologywith Community Health, Vidyasagar University, Midnapur, West Bengal, India

Received: 04 March 2017/Revised: 17 May 2017/Accepted: 20 June 2017

ABSTRACT- The bell metal works is the oldest cottage industries mainly clustered around the Bankura, Purulia and Medinipur (W) districts in West Bengal, India. The smelting, hammering, scraping and paddle rolling are the most predominant activities in their Bell Metal work process. During work, different types of metal fumes are sublimated to their working environment. The present study was to investigate the prevalence of pulmonary dysfunctions of these workers. 363 workers were randomly selected by them 263 were exposed and 100 were control workers. The prevalence of pulmonary symptoms was determined by a standardized questionnaire. Pulmonary indices viz. FVC%, FEV1%, $FEF_{25\%–75\%}$, FEV1/FVC%, MVV-Index and PEFR were measured by a digital spirometer and smoking frequency was determined by Nitti Index. Study results revealed that there were significant differences in height ($p<0.05$), weight and BMI ($p<0.001$) between the exposed and control groups. All pulmonary indices were significantly ($p<0.05$ or less) lower in exposures than controls. The prevalence of different pulmonary diseases viz., COPD ($p<0.05$), asthma ($p<0.001$), wheezing ($p<0.01$) and breathlessness ($p<0.001$) were significantly higher in exposures than that of the control. It was concluded that the exposures had reduced pulmonary capacity, which might be due to expose of different gases, fumes and other pulmonary irritants. The occurrences of pulmonary diseases were higher in bell metal workers than that of non-exposed workers. Smoking and work experience may be additive adverse effect on it.

Key-words- Bell Metal Worker, Pulmonary diseases, pulmonary capacity, Smoking

INTRODUCTION

Bell metal is an alloy consisting mainly of 78% copper (Cu) and 22% of tin (Sn) in 78:22. In addition, it may contain metals such as lead (Pb), cadmium (Cd), silica (Si), zinc (Zn), iron (Fe), arsenic (As) etc, which may be added intentionally to improve the quality of the alloy or may be present as impurities.

Access this article online	
Quick Response Code	Website: www.ijlssr.com
	DOI: 10.21276/ijlssr.2017.3.4.14

This alloy manufacturing, which is usually done at home in small and medium scales (SMSc) industries, is one of the oldest cottage industries in Nepal, China, Japan, Korea, Thailand and in India, including West Bengal state, from the ancient time [1]. It is an industry, which had been handed over from generation to generation.

The processes which were totally manual have not been mechanized till now. Tin and copper are scrap metal, smelted at an above 232°C and 1084°C respectively [2] by using coal and poured into sand casts of various shapes to prepare a bell ingot. During smelting and casting, different types of metal fumes (e.g. copper, tin, lead, silica etc) are sublimated to their working environment. Bell and silica, tin, coal dust may be released during fettling and polishing. Gases such as metal oxides, formaldehydes, PAHs CO, ozone, oxides of nitrogen, Sulpher [3], acetylene and phosphine are also liberated during welding [4]. These pollutants may pose a threat to the pulmonary health of these alloy foundries and manufacturing plant workers as there are no control measures such as exhaust ventilation systems installed in this type of foundry industries [5].

The pulmonary health effects have been documented in workers cumulative prolonged exposed to a variety of dust, gases and metal fumes in small and large-scale industries which breed during their production process [6]. It was reported that pulmonary diseases are influenced by their types of inhaled substance, doses, duration of exposures and genetic factors. Occupational pulmonary diseases are caused by a pathologic response of the subjects to their working environment [4] including the chemical nature and physical state of the inhaled substance, the size and concentration of the dust particles and individual susceptibility [7]. Other demographic variables have been shown to affect lung function, including age, weight, smoking, and socioeconomic conditions [8].

Studies of occupational groups such as hard rock miners, smelter workers, and rubber workers suggested that exposure to irritant gases (Tin oxides, SO_2) increase the prevalence of pulmonary symptoms [9]. It was reported that exposure to airway disease gases combined with heat or dust caused the accelerated decline of FEV_1 [10] and the exposure of carbon dust to be associated with chronic bronchitis, symptoms such as cough wheezes and phlegm as well as impaired pulmonary function and pulmonary disorders marked by significant decrements in FVC and FEV1. In addition, tobacco smoking decreases pulmonary functional indices which were significantly associated with COPD (chronic obstructive pulmonary disease) [11].

The epidemiological evidence supporting the role of occupational exposures (organic and inorganic dusts, metal fumes, chemical vapours) as risk factors for pulmonary diseases has been published in population-based studies [12] and also studied regarding working environments with specific exposures. In 2013, National Board of Industrial Injuries in Denmark was reported about 19% of construction workers exposed to dust, fibres, smoke and exhaust fumes (Danish Working Environment Authority annual report, 2015) [13]. There was a tendency toward more self-reported symptoms of bronchitis in male Danish construction workers than comparable to hospital porters and a tendency toward higher prevalence of $FEV_1 <$ LLN (lower limit normal) in demolition workers compared to insulators and carpenters.

According to the World Bank and WHO Global Burden of Disease report, COPD is the sixth leading cause of death in developing countries, responsible for 4.9% of deaths [14]. In developing countries, smoking, COPD is associated with the highest burden of lung diseases (BOLD) [15].

A very little research has been conducted in the past to determine the health hazards faced by the bell metal foundry workers. Thus, it was felt important that a survey be conducted in order to identify them. This study was conducted to investigate the effects of exposure to polluted agents of bell metal foundries on pulmonary functions of bell metal workers and to access the additive effect of smoking on those parameters.

MATERIALS AND METHODS

This cross-sectional study was conducted on 363 bell metal workers in different bell metal workshops located in Bankura, Purulia and Paschem Medinipur districts of West Bengal, India from November, 2014 to December, 2015. The eligibility criterion for the recruitment of the participants in the present study was work experience of at least 4 years or above. The workers were divided into three age group e.g. Group-A (≤30 years), Group-B (31-45 years) and Group-C (>45 years) Subjects with any past or present history of major chronic diseases like tuberculosis, diabetes mellitus, and hypertension and other major respiratory illness and subject using any protective equipment at working place were excluded from the study. The authors disqualified 35 (9.69%) participants because they were not eligible by the criteria.

Among the 326 eligible, 42 participants were not interested to participate in the present study. Among the 284 participants, 21 participants were excluded from the study due to missing or incomplete data. Thus, a final of 263 (80.67% of eligible) workers participated in the present study. In addition, a group of age matched 100 subjects were taken as control subjects (unexposed). Ethical approval and prior permission was obtained from the institutional Ethics Committee before commencement of the study and the study was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration. Before the start of data collection, the purpose of the study and procedures of data collection was explained verbally in detail in local language (Bengali) to the participants during field visits to obtain their understanding and cooperation. The participants agreeing to take part in the study, written and signed consent was obtained.

The two-stage sampling method was utilized. At first, a cluster sampling method was utilized to identify 10 clusters (bell metal cluster area) in each district e.g., Bankura and Purulia districts of West Bengal, India. In the second stage, a systematic random sampling method was utilized to identify 20 participants per cluster. All participants in the cluster were listed and the number of the participant was divided by the required number to get the sampling interval. The first participant was chosen randomly using a lottery method and then subsequent participants were selected by the adding sampling interval to the random number.

Measurement of anthropometric dimensions

Anthropometric measures were taken from the participants following standard technique and appropriate landmarks. Height was measured to the nearest 0.1 cm using anthropometer (Hindustan Minerals) and weight to the nearest 0.1 kg using portable weighing machine (Libra).

Assessment of pulmonary problems

All subjects were interviewed with a questionnaire. The questionnaire included work history, respiratory symptoms (cough, phlegm, dyspnoea, wheezing, & chest tightness), and smoking status of the study participants followed by the American Thoracic Society questionnaire-ATS-DLD-78a [16].

Smoking Index

According to Nitti, the study participants were classified into three categories of smoker viz. **(1) Mild smokers:** Smoking Index less than 200, **(2) Moderate smokers:** Smoking Index 200-400, and **(3) Heavy smokers:** Smoking Index more than 400. Smoking Index= (number of cigarettes/ 'biri' (a handmade cigarette) smoked daily multiplied by the number of smoking years) [17].

Pulmonary Function Test (PFT)

Different pulmonary functional variables, Viz., FVC, FEV1, FEF, FEF 50%, FEV1/FVC of the bell metal workers as well as control subjects (age matched apparently healthy sedentary men) were measured by a portable PC based MICRO-DATO Spirometer (Sibelmed, Barcelona) in standing position. Measurements were carried out according to standard protocols of the American Thoracic Society guidelines [18]. Participants were instructed to take maximum inspiration and the blow as rapidly, forcefully and completely as possible followed by full and rapid inspiration to complete the flow volume loop. The best of the three trials was considered for data analysis.

STATISTICAL ANALYSIS

Data analyses were made using the IBM Statistical Package for Social Science (SPSS) version 20. Sample proportions were compared by Chi square test. Multiple linear Regression (MLR) analysis was applied to identify the factors associated with lung function values. The outcome variables analyzed were Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second (FEV1), FEV1/FVC%), Peak Expiratory Flow (PEF), FEF25%–75% and MVV (Maximal voluntary ventilation) Index. The significant level used for evaluating the test of significant at p-value 0.05 or less.

RESULTS

A total 363 male participants were included in this study. Of these, 263 bell metal workers were treated as exposed group and 100 participants were in the unexposed group (control). The age of the exposed workers ranged between 18–60 years with a mean value 41.14±11.8 years, while the age of the control group ranged between 20-60 years with a mean of 39.56±12.28 years (Table 1). Among the study participants, non-smokers were about 52.85%, of whom 47.15% were in exposed group and 42% were in control group (Table 2). Different pulmonary function parameters of the bell metal workers were compared with the control participants. From the results it was observed that all pulmonary function variables (FVC, FEV1, FEV1/FVC%, PEF, $FEF_{25\%–75\%}$, MVV index) were significantly lower ($p<0.05$ or less) among the bell metal workers compared to that of control group (Table 1).

Table 1: Physical characteristics and pulmonary functional parameters of bell metal workers and control group

Variables	Bell metal workers (n= 263)		Control subjects (n= 100)	
	Mean±SD	Range	Mean±SD	Range
Age (yrs)	41.14±11.8	18-60	39.56±12.28	20–60
Height (cm)	162.27±4.26	146.4-179	163.56±5.81*	142–176
Weight (kg)	53.21±5.26	42-74	57.45±7***	39–81
BMI	20.18±1.5	17.01–27.01	21.48±2.51***	15.78–32.47
FVC (liter)	3.17±0.71	1.26–5.49	3.43±0.69**	1.89–5.59
FEV1 (liter)	2.54±0.66	0.8–-4.55	3.01±0.52***	1.32–3.91
FEV1/FVC (%)	81.42±10.53	59.82–100	88.69±7.77***	61.9–99.7
PEF (liter/sec)	6.22±1.97	1.68–10.42	7.02±1.67***	2.61–10.4
$FEF_{25\%-75\%}$ (liter/sec)	3.27±1.18	0.45–6.75	4.01±3.01*	0.91–32.33
MVV-Index (liter/min)	81.66±19.05	26.85–136.45	90.07±19.24***	39.6–116.22
Work experience (Years)	24.05±11.26	4–48	–	–

w.r.t (with respect to) control group *$p<0.05$; **$p<0.01$;*$p<0.001$**

The study participants were classified into three groups according to their age and the pulmonary functions were compared in different age groups (Table 2). From the results it was revealed that the pulmonary functions showed significant variation in different age groups and the ventilatory parameters were progressively decreased with the advancement of age ($p<0.001$).

The Posthoc analysis of different lung function parameters between different age groups was done. In comparison between the age group ≤30 years and 31 to 45 years, it was revealed that all the pulmonary parameters (e.g. FVC, FEV1, FEV1/FVC, PEF, $FEF_{25\%–75\%}$ and MVV-Index were decreased in 31 to 45 years age group than age group ≤30 years. But in age group 31 to 45 years, FEV1, FEV1/FVC and $FEF_{25\%–75\%}$ values were decreased significantly ($p<0.001$) and FVC and PEF values did not change significantly. In addition, there were significantly decreased in FVC ($p<0.01$), FEV1 ($p<0.001$), FEV1/FVC ($p<0.001$), PEF ($p<0.05$), $FEF_{25\%-75\%}$ ($p<0.05$) and MVV Index ($p<0.05$) when these results compared between the age group 31 to 45 years and >45 years. It was also revealed that all these pulmonary parameters were decreased significantly ($p<0.001$) we compared between age group >45 years and age group ≤30 years. Again, when of all pulmonary parameters we compared among all age groups the results (F values) showed significant variation ($p<0.001$).

Table 2: Mean ± SD of pulmonary functions of bell metal workers in different age groups

Pulmonary parameters	**Age Group (Years)**			**F-ratio**
	≤30 (n=67)	**31 to 45 (n=92)**	**>45 (n=104)**	
FVC (liter	3.38±0.7	3.25±0.55	2.97±0.78***##	8.477†††
FEV1(liter)	3.03±0.54	2.72±0.51***	2.05±0.51***###	80.923†††
FEV1/FVC (%)	90.36±6.43	84.41±7.54***	72.89±8.48***###	115.819†††
PEF (liter/sec)	6.99±1.41	6.58±1.76	5.41±2.17***#	17.442†††
$FEF_{25\%-75\%}$ (liter/sec)	4.09±0.86	3.4±0.99***	2.62±1.14***#	43.91†††
MVV-Index (liter/min)	92.58±15.55	85.12±14.64**	71.56±19.7***#	33.95†††

w.r.t. Age Group ≤30 years; **p<0.01;*p<0.001;**
w.r.t. Age Group 31 to 45 years ###p<0.001 and
w.r.t. Age Group ≤30 years and Age Group >45 years †††p<0.001

Table 3 showed the changes in pulmonary parameters with duration of exposure (denoted by years of experience) in bell metal workers. As there was an increase in the duration of exposure there was a gradual decline in mean values of all the pulmonary variables. The FVC in group A (duration of exposure (≤15 years) was found to be 3.37±0.67L which significantly decreased gradually as duration of exposure was increased. Similarly, FEV1, FEV1/FVC (%), PEF, $FEF_{25\%-75\%}$ and MVV-Index were also found to be decreased significantly ($p<0.001$) as the duration of exposure was increased.

Different respiratory symptoms and disorders among the workers and control group have been presented in Table 4. Statistical analysis (Chi square test) showed, the prevalence of COPD among the bell metal workers (31.56%) was significantly ($p<0.001$) higher than that of the control group. A large percentage of the bell metal workers reported to have breathlessness (41.83%), asthma (26.62%), and wheezing (22.43%). The occurrence of these symptoms were significantly ($p<0.001$) higher in bell metal workers than that of the control (unexposed) group.

Table 3: Comparisons in pulmonary function indices (Mean±SD) stratified by working experience of bell metal workers

Pulmonary parameters	Work Experience Group (Years)			F ratio
	Group A (≤15 yrs) (n=78)	Group B (16-30 yrs) (n=107)	Group C (>30 yrs) (n=78)	
FVC (liter)	3.37±0.67	3.15±0.64*	3.02±0.78**	5.155††
FEV1(liter)	3.02±0.52	2.6±0.55***	2.01±0.49***###	75.752†††
FEV1/FVC (%)	90.33±5.62	83.48±8.3***	70.58±6.35***###	166.405†††
PEF (liter/sec)	7.04±1.4	6.29±1.89**	5.3±2.19***##	17.248†††
$FEF_{25\%-75\%}$ (liter/sec)	4.05±0.83	3.22±1.0***	2.55±1.23***###	41.054†††
MVV-Index (liter/min)	91.91±15.05	81.74±16.63***	71.29±20.23***###	27.473†††

w.r.t. Group A *p<0.05; **p<0.01;*p<0.001**
w.r.t. Group B #p<0.05; ##p<0.01; ###p<0.001
w.r.t. Group A and Group C †† p<0.01; ††† p<0.001

Table 4: Prevalence of pulmonary symptoms/ disorders among exposed (bell metal workers) and non-exposed (controls) workers

Pulmonary symptoms	Exposed group (n= 263)	Control Group (n= 100)
COPD	31.56%	3%***
Asthma	26.62%	7%***
Wheezing	22.43%	10%***
Breathlessness	41.83%	13%***
Chest Cold	11.41%	14%
Bronchitis	3.42%	4%

w.r.t Exposed group ***p<0.001

Logistic regression was used to assess the levels and impacts of age, smoking habit and work experience of the bell metal workers on COPD prevalence (Table 5). After adjustment of all potential factors, it was revealed that the most predominant risk factor for COPD among workers were work experience (year of exposure) and smoking. Indeed, COPD was significantly greater ($\chi2$=9.548, p<0.01) in smokers than non-smokers. The smokers had 2.55 times higher risk of COPD than that of non-smokers. The prevalence of COPD was the maximum in experienced group (>30 years) and it was gradually increased with the advancement of work experience and age. It was most prevalent among the workers having >30 years of experience ($\chi2$ =168.695, p<0.001) as well as among the workers having >45 years of experience ($\chi2$=109.297, p<0.001).

The COPD increases significantly ($\chi2$=168.695, (p<0.001) in all experienced (minimum 4 years experience) workers than young, experienced and same trend was found in all age variables of the workers ($\chi2$=109.297, p<0.001). It was revealed that highly experienced workers (>30 years) had (p<0.001) higher risk of COPD (AOR=322.6, 10.12-1028.75) than that of less experienced workers (≤15 years).

Table 5: Logistic regression shows unadjusted and adjusted odd ratio of COPD by smoking, work experience and age groups of the bell metal workers

Variables		n	COPD%	χ2	COR	95th CI	AOR	95th CI
Smoking	Yes	124	41.13	9.548	2.34**	1.37-3.98	2.55*	1.11-5.87
	NO	139	23.02	(p<0.01)	1			
Work experience (years)	≤15	77	1.28	168.695	1			
	16 to 30	103	12.15	(p<0.001)	10.98*	1.4-85.85	9.33*	0.39-224.12
	>30	83	88.46		374.57***	47.99-2923.54	322.6***	10.12-10282.75
Age group (years)	≤30	67	1.49	109.297	1			
	31 to 45	93	11.96	(p<0.001)	8.85*	1.11-70.35	1.13	0.04-28.16
	>45	103	68.27		146.44***	19.46-1102.1	1.19	0.4-37.16

COR= Crude Odd Ratio, AOR= Adjusted Odd Ratio
p<0.05; **p<0.01;p<0.001**

DISCUSSION

This cross-sectional study revealed the temporal association between bell metal workers (exposed group) and the control subjects (non-exposed group). The bell metal workers had a significantly higher prevalence of chronic pulmonary symptoms in comparison to the control group. This might be attributed to the fact that the bell metal workers were exposed to a variety of chemicals, gases and fumes evolved in the workplace. This finding was in agreement with other studies carried out on different foundry workers [19, 5]. Like other foundry workers, the bell metal workers have reported to exhibit a variety of clinical manifestations, including asthma, cough, phlegm, wheezing, metal fume fever, impairment of pulmonary functions and COPD.

Initially, smoking index and duration of work experience were significantly associated with the pulmonary capacity, when age was a covariate, which was included in the regression that no longer became significant. Thus, the smoking is independent factor which usually reported to impair pulmonary function; in this study smoking was found to further exacerbate pulmonary function in bell metal workers. Furthermore, both work experience and smoking index were known to be associated with age, thus lead to presence of the individual pulmonary adverse effects. In human, silica and coal dust, metal fumes have been shown to produce emphysema in highly-exposed alloy manufacturer [20].

Declines in FEV1, FEV1/FVC were the indicators of pulmonary obstructive abnormalities [21]. Decrease in pulmonary parameters, especially FEV1 was the first measurable sign of the initiation of bronchitis and obstructive lung disease in smokers [22], which were shown in our study population an official report of the American Thoracic Society documented the relationship between occupational exposures and an increased risk in chronic cough, lower FEV1, and a lower FEV1/FVC [23].

In general, all pulmonary parameter's value reduced in all smoker categories (Table 2). It was most important that smokers had lower pulmonary values when it was compared to non-smokers in the bell metal worker. The result suggests that smoking affects the lung capacity, making the volume that is associated with the FVC test smaller than that of non-smokers. The reduction in FVC of smoker may be explained by the reduction in strength of the respiratory muscles. Smoking affects the respiratory muscles through the influence of free radicals on the vascular system [24], leading to a reduction in respiratory muscle blood supply which adversely impacts respiratory function. Smoking may be attributed to greater airway obstruction because smoke, which causes direct irritant and toxic effect on airways and pulmonary parenchyma by the mechanism of oxidative injury [25]. Another research found that FEV1 was decreased by 0.42 ml for each bidi/cigarette smoked per day [26]. Obstructive pulmonary dysfunction is more common in young adult smokers with impaired pulmonary functions who have been apparently healthy [27].

Reduction of $FEF_{25\text{-}75}$% was an indicator of small airway obstruction also. A significant dose response (length of work experience) was seen even with the addition of age, which might establish the small airway function that was the first to get affected as a result of contact to pulmonary pollutants [28]. On the other hand, pulmonary function indices (FEV1, FVC, FEV1/FVC) in bell metal workers significantly decreased from the lower age group to a higher age group (<30 years to 31–45 years and ≥45 years) and with length of experience successively, representing that the pulmonary ventilation capacity of exposed workers would decrease with the increasing length of work experience. Vidja *et al.* [29] was reported the similar observations.

Some investigators showed that decrease in PEF might be due to a significant reduction in expiratory and inspiratory flow rate. The low volumes PEF of the workers indicated flow rates in the small airways i.e. this with internal diameters of <2 mm. This might be decreased at small lung volumes both in restrictive and obstructive diseases [30]. In the present study, obstructive lung was observed, which might be due to inflammatory reactions, respiratory irritation, and the resultant narrowing of the airways caused by metal dust and mist. Similar agreement has been made by the US Department of labour [31].

There was a significant decline in MVV-Index in successively exposed and aged workers. The MVV-Index showed all mechanical factors of breathing. Decreased value of MVV-Index indicated an increase in airway resistance, decreased lung compliance or reduced respiratory muscle force [32].

When one develops lung disease, one's lungs are no longer able to take in enough air. Additionally, many people, who have lung disease have improperly functioning air sacs in the lungs, so the oxygen that a person takes not fully absorb into the blood. This implied that other mechanisms than bronchial obstructions were involved. The long term exposure of these pulmonary pollutants to the working environment could cause the occurrence of interstitial fibrosis and pulmonary nodules, thereby affecting the function of pulmonary ventilation and air exchange [33].

In this study, we examined the relation between pulmonary symptoms and occupational exposures of the bell metal workers and we found high risk for the occurrence of COPD, asthma, wheezing and breathlessness among the workers after adjusting age and smoking habits. A study of Obstructive Lung Disease in Northern Sweden also certified determination of the proportion of COPD cases i.e. due to smoking [34]. By using the GOLD criteria for the diagnosis of COPD, the population attributable high risk of COPD for smoking was 45% in the age group of >45 years. The particles generated during copper and tin processing were probably smaller in size during bell metal work. These small metal particles, by virtue of their greater surface area to mass ratio, could carry a much larger fraction of toxic compounds, such as hydrocarbons, Si, Cu and Sn etc metals on their surface. Importantly, they remain airborne for long periods and deposit in greater numbers and deeper into the lungs than larger particles do [35]. Therefore, chronic exposure to these small particles could lead to chronic inflammation of the respiratory tract and lung parenchyma in bell metal workers.

Occupational asthma became the second prevalent pulmonary disease following pneumoconiosis. It was reported to be associated with several occupation groups in the literature, including automobile and furniture painters, welders, textile workers, paper factory workers, plastics manufacturers, farm workers, and chemical processors [36]. The bell metal foundry workers also had a high risk of occupational asthma. In addition, it was formerly reported that there are an increased number of lung cancer cases among foundry workers [18]. In our study, we found that there was an increase in occupational asthma with a moderate degree of bronchitis among the bell metal workers and did not find any case of pneumoconiosis and lung cancer in the bell metal workers. But long-term follow-up is needed to analyze the risk of neoplastic disease and pneumoconiosis in these workers. High prevalence of occupational asthma in foundry workers due to expose of the high concentration of air contaminants and smoking had an additive effect on the pulmonary system [7]. Wheezing and breathlessness is also associated with asthma [37].

CONCLUSIONS

The bell metal workers were observed to have a high risk of developing pulmonary symptoms and a decrease in pulmonary capacity. All pulmonary parameters like FEV1, FEV1/FVC, FEF_{25-75}%, and PEF and MVV index were lower than that of control subjects. Bell metal with smoking habit, however, showed a higher value of FVC in comparison to control subjects and the reason(s) for this remained unclear and required further elucidation. Advancement of age with long work experience and smoking habit were the important causative factors of higher prevalence of COPD among the bell metal workers. It was difficult to isolate the main causative factor for the same, as there were several pulmonary pollutants in which the bell metal workers were exposed in multiple tasks within their workplace. The effects observed might be as a result of combination of exposures of different pollutants present in their working environment. Encouragement of smoking cessation and adoption of technical preventive measures, such as having well ventilated work station, health education program and wearing protective masks was needed to reduce the respiratory impairment. It was suggested that bell metal workers must undergo periodic medical surveillance test (spirometry and STP test) in order to reduce the pulmonary hazards.

ACKNOWLEDGMENT

The authors are grateful for the continuing voluntary participation of the bell metal workers in the bell metal cluster areas of three districts of West Bengal, India. We also appreciated many people, who have cooperated in the collection of data.

REFERENCES

[1] Srinivasan S. Bronze image casting in Tanjavur District, Tamil Nadu: Ethnoarchaeological and archaeometallurgical insights, NIAS book: SP7, 2015; 209-16.

[2] Periodic Table: Royal Society of Chemistry, 2016. Registered charity number: 207890. http://www.rsc.org/periodic-table/element/29/copper and http://www.rsc.org/periodic-table/element/49/indium.

[3] McLaughlin J, Seow A, Duell EJ, Andrew AS, Zaridze D, et al. In-home coal and wood use and lung cancer risk: a pooled analysis of the International Lung Cancer Consortium. Environ. Health Perspect., 2010; 118(12): 1743-47.

[4] Jayawardana PL, De Alwis WR, Fernando MA. Ventilatory function in brass workers of Gadaladeniya, Sri Lanka. Occup. Med., 1997; 47(7): 411-6.

[5] Morteza MM, Hossein K, Amirhossein M, Naser H, Gholamhossein H, Hossein F. Designing, construction, assessment, and efficiency of local exhaust ventilation in controlling crystalline silica dust and particles, and formaldehyde in a foundry industry plant. Arch. Industrial Hygiene Toxicol., 2013; 64(1): 123-31.

[6] Mohammadien, Hamdy A., Mona T. Hussein, and Raafat T. El-Sokkary. Effects of exposure to flour dust on respiratory symptoms and pulmonary function of mill workers. Egyp. J. Chest Dis. Tubercul., 2013; 62(4): 745-53.

[7] Kayhan S, Tutar U, Cinarka H, Gumus A, Koksal N. Prevalence of occupational asthma and respiratory symptoms in foundry workers. Pul. Med., 2013; 2013: 1-4.

[8] Menezes AM, Dumith SC, Perez-Padilla R, Noal RB, Wehrmeister FC, et al. Socioeconomic trajectory from birth to adolescence and lung function: prospective birth cohort study. BMC public health, 2011; 11(596): 1-7.

[9] Sun LH, Zhang NY, Zhai QH, Gao X, Li C, Zheng Q, Krumm CS, Qi D. Effects of dietary tin on growth performance, hematology, serum biochemistry, antioxidant status, and tin retention in broilers. Biol. Trace Element Res., 2014; 162(1-3): 302-08.

[10] Nordby KC, Notø H, Eduard W, Skogstad M, Fell AK, Thomassen Y, Skare Ø, Bergamaschi A, Pietroiusti A, Abderhalden R, Kongerud J. Thoracic dust exposure is associated with lung function decline in cement production workers. European Respir. J., 2016; 48(2): 331-39.

[11] Neghab M, Mohraz MH, Hassanzadeh J. Symptoms of respiratory disease and lung functional impairment associated with occupational inhalation exposure to carbon black dust. J. Occup. Heal., 2011; 53(6): 432-38.

[12] LeVan TD, Koh WP, Lee HP, Koh D, Mimi CY, London SJ. Vapor, Dust, and Smoke Exposure in Relation to Adult-Onset Asthma and Chronic Respiratory Symptoms the Singapore Chinese Health Study. Am. J. Epidemiol., 2006; 163(12): 1118-28.

[13] Hanskov D, Brauer C, Breinegaard N, Kirkeskov L. Respiratory symptoms and lung function among Danish construction workers. A cross-sectional study. Int. J. Respir. Pulm. Med., 2015; 2(4): 1-6.

[14] Kraïm-Leleu M, Lesage FX, Drame M, Lebargy F, Deschamps F. Occupational Risk Factors for COPD: A Case-Control Study. PLoS One, 2016; 11(8): 1-11.

[15] Denguezli M, Daldoul H, Harrabi I, Gnatiuc L, Coton S, et al. COPD in nonsmokers: reports from the Tunisian population-based burden of obstructive lung disease study. PloS one, 2016; 11(3): 1-17.

[16] Ferris BG. Epidemiology Standardization Project (American Thoracic Society). Am. Rev. Resp. Dis., 1978; 118(6 Pt 2): 1-20.

[17] Nitti V. Epidemiological survey of chronic obstructive pulmonary disease in the city of Naples with particular reference to the role of various exogenous factors. Bull. Int. Union Tuberc., 1976; 51: 10.

[18] Miller MR, Hankinson JA, Brusasco V, Burgos F, Casaburi R, Coates A, Crapo R, Enright P, Van Der Grinten CP, Gustafsson P, Jensen R. Standardisation of spirometry. European Resp. J., 2005; 26(2): 319-38.

[19] Wong JYY, Bassig BA, Seow WJ, Hu W, Ji BT, et al. Lung cancer risk in welders and foundry workers with a history of heavy smoking in the USA: The National Lung Screening Trial. Occup Environ Med., 2017; 74(6): 440-48.

[20] Rodríguez E, Ferrer J, Zock JP, Serra I, Antó JM, et al. Lifetime occupational exposure to dusts, gases and fumes is associated with bronchitis symptoms and higher diffusion capacity in COPD patients. PloS one, 2014; 9(2): 1-7.

[21] Conway F, Majeed A, Easton G. Diagnosing chronic obstructive pulmonary disease. BMJ: British Med. J., 2015; 351: h617.

[22] Rogliani P, Puxeddu E, Ciaprini C, Ora J, Onorato A, Pezzuto G, Calzetta L, Cazzola M. The Time Course of Pulmonary Function Tests in COPD Patients with Different Levels of Blood Eosinophils. BioMed. Res. Int., 2016; 2016: 1-7.

[23] Hines SE, Barker EA, Robinson M, Knight V, Gaitens J, Sills M, Duvall K, Rose CS. Cross Sectional Study of Respiratory Symptoms, Spirometry, and Immunologic Sensitivity in Epoxy Resin Workers. Clin. Translational Sci., 2015; 8(6): 722-28.

[24] Ambrose JA, Barua RS. The pathophysiology of cigarette smoking and cardiovascular disease: an update. J. Am. Coll. Cardiol., 2004; 43(10): 1731-37.

[25] Salih SI, Al-hindawi AA. Investigation of the Pulmonary Function Tests in Young Adults Smokers. UK J. Pharmaceut. Biosci., 2015; 3(4): 39-42.

[26] Lee PN, Fry JS. Systematic review of the evidence relating FEV 1 decline to giving up smoking. BMC Med., 2010; 8(84): 2-29.

[27] Solanki JD, Gadhavi BP, Mehta HB, Makwana AH, Shah CJ, Gokhale PA. Deterioration of lung functions is similar in bidi and cigarette smokers in younger population despite mild, low duration smoking-an observational study. Int. J. Clinical Exp. Physiol., 2016; 3(2): 66-71.

[28] McNulty W, Usmani OS. Techniques of assessing small airways dysfunction. European clin. Respir. J., 2014; (1): 1-17.

[29] Vidja K, Bhabhor M, Paramar D, Kathrotia R, Dodhia S, Mehta N. A comparative study of pulmonary functions in different age groups. NJIRM, 2013; 4(3): 13-17.

[30] Chaabane Z, Murlasits Z, Mahfoud Z, Goebel R. Tobacco Use and Its Health Effects among Professional Athletes in Qatar. Canadian Respiratory Journal, 2016; 2016:1-5.

[31] Occupational Health Guideline for copper dusts and mists. US Department of labour: Occupational Safety and Health Administration 1978. Available from www.cdc.gov/niosh/docs/81-123/pdfs/0150, pdf (Accessed April 27, 2015).

[32] Villiot-Danger JC, Villiot-Danger E, Borel JC, Pépin JL, Wuyam B, Verges S. Respiratory muscle endurance training in obese patients. Int. J. Obes., 2011; 35(5): 692-99.

[33] Qian QZ, Cao XK, Qian QQ, Shen FH, et al. Relationship of cumulative dust exposure dose and cumulative abnormal rate of pulmonary function in coal mixture workers. Kaohsiung J. Med. Sci., 2016; 32(1): 44-49.

[34] Andreeva E, Pokhaznikova M, Lebedev A, Moiseeva I., Kozlov A, et al. The respect study: research on the prevalence and the diagnosis of copd and its tobacco-related etiology: a study protocol. BMC Public Health, 2015; 15: 831-41.

[35] Global Strategy for Asthma Management and Prevention, “Global Initiative for Asthma (GINA),” http://www.ginasthma.org/local/uploads/files/GINAReport March13.pdf, 2012.

[36] Sharma AV, Ajmani S, Vishnusharma M, Ganaraja B, Subbalakshmi NK, et al. An analysis of dynamic pulmonary function in automobile mechanics. Int. J. Biomed. Res., 2012; 3(8): 374-77.

[37] Arora S, Tripathi Y, Malhotra V, Garg R, Goel N, et al. Evaluation of Pulmonary Function in Car Spray Paint Sprayers. Int. J. Life Sci. Scienti. Res., 2016; 2(5): 588-91.

How to cite this article:
Das NK, Mahata H, Dhara PC: Evaluation of Pulmonary Capacity and Prevalence of Pulmonary Dysfunctions of Bell Metal Workers in Relation to their work Experience and Smoking Habit. Int. J. Life Sci. Scienti. Res., 2017; 3(4):1181-1189. DOI:10.21276/ijlssr.2017.3.4.14

Source of Financial Support: Nil, **Conflict of interest:** Nil