Original Article

DOI: JCDR/3975:0000

Internal Medicine Section

Pulmonary Function Impairments among Dry Cell Battery Factory Workers

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ABSTRACT

Context: Inhalation of the ingredients which are found in a dry cell battery factory can affect the pulmonary function of its workers.

Aims: To evaluate the impact of the dry cell battery exposure on the pulmonary function of exposed workers by using spirometric parameters and its correlation with the duration of the exposure.

Settings and Design: Cross sectional, randomised study.

Methods and Material: A standard questionnaire was followed to note the symptoms like cough, breathlessness, morning cough and chest tightness. In the present study, the pulmonary function status assessment was done by a spirometric method by using Spirovit-SP-10 and Wright's peak flow meter. Out of the total subjects who were studied (n = 119), 60 were control subjects and 59 were workers who were exposed to the ingredients of a dry cell battery.

Statistical Analysis Used: The unpaired t-test was done to determine the significant difference between the battery workers and the control subjects. We also checked whether there was any correlation between the pulmonary function status and the duration of the exposure at work.

Results: A few workers reported symptoms of cough, breathlessness, morning cough and chest tightness. The respiratory symptoms were found to be higher in the exposed dry cell battery factory workers (32.75%) as compared to the control subjects (12.65%). A trend of decrement of the lung volumes with an increment in age and the duration of the work exposure was observed. The pulmonary function abnormalities which were found among the male dry cell battery factory workers were of the obstructive (18.5%), restrictive (5.6%) and the mixed (4.5%) types.

Conclusions: The respiratory impairments among the dry cell battery workers could have been due to their exposure to the work environment. The longer the duration of the exposure, more was the pulmonary function decline.

Key Words: Dry cell battery, Spirometry, FEV_1, FEV_1/FVC

INTRODUCTION

In our day to day life, we use dry cell batteries to run our electronic accessories like cell phones, radios, torches, etc. The ingredients of these dry cell batteries are cadmium as cadmium metal, cadmium oxide and cadmium hydroxide; cobalt as cobalt metal, cobalt oxide and cobalt hydroxide; lithium hydroxide; nickel as nickel metal, nickel oxide and nickel hydroxide; potassium hydroxide and sodium hydroxide, manganese in the form of manganese dioxide and carbon black. The ingestion of the open battery content can cause serious chemical burns of the mouth, oesophagus and the gastrointestinal tract. The contents of an open battery can cause respiratory irritation due to their inhalation. The cadmium oxide fumes can cause metal fume fever. The hypersensitivity to nickel can cause allergic pulmonary asthma [1, 2, 3]. For the occupational lung diseases, spirometry is the most widely used instrument to assess the pulmonary function status of a subject and it can measure and judge the restriction or obstruction if any, to the lung function [4]. The most important component in the dry cell battery, which is associated with respiratory hazards, is cadmium. Cadmium, a known cause of emphysema in an occupational setting, may be important in the development of tobacco related lung disease [5].

This study will help in evaluating the respiratory functional status of the male dry cell battery workers who are exposed to the ingredients of the battery during their work and in making them aware of the methods which control the health hazards due to the making of a dry cell battery, as well as in implementing preventive measures with regards to the exposure and the consequent occurrence of the respiratory impairments.

METHODS

This study was carried out in the suburbs of Kolkata, West Bengal, India. Of the total subjects who were studied (n = 119), 60 were control subjects and 59 were workers who were exposed to the dry cell battery factory ingredients. The control subjects were selected from those in the population who were not directly engaged in dry cell battery making, but were associated with other jobs in the same area of the study. All the subjects who were included in this study were nonsmokers and non-alcoholics. Subjects who were already diagnosed with respiratory diseases like tuberculosis, asthma, chronic obstructive pulmonary disease, etc. in the past or present or those who had any major medical or surgical illnesses were excluded from the study. A screening chest X-ray (CXR) was done for all the subjects and the subjects with an abnormal chest X-ray were excluded from this study. A written informed consent was taken from all subjects before the start of the study.

PULMONARY FUNCTION TESTS

The forced vital capacity (FVC) was recorded by using Spirovit-SP10 (Schillar Health Care Pvt. Ltd., Switzerland) and the peak expiratory flow rate (PEFR) was recorded by using Wright's peak flow meter (Clement and Clark, UK). The forced expiratory volume in one second (FEV_1), the FEV_1/FVC ratio and the forced expiratory flow rate at 25-75% ($FEF_{25-75\%}$) were calculated from the same tracing. Before the recordings were taken, all the subjects were well motivated to ensure that the recordings were done at optimum levels [6]. The spirometric measurements were made with the subjects in a comfortable sitting position. The body height and body weight were measured by using a standard scale without wearing footwear. All the measured lung volumes which were obtained were expressed in terms of body temperature pressure which was saturated with water vapour [7]. The body surface area was calculated by using the Du-Bois and Du-Bois formula [8]. The pulmonary function test values were predicted from the standard prediction equation of the normal subjects in Kolkata [9]. The criteria which was followed for the categorization of the lung function impairment (obstructive or restriction) was based upon the value of FEV_1/FVC and the categorization of the severity which was based upon the FEV_1 % which was predicted [10].

STATISTICAL ANALYSIS

For the data analysis and the statistical calculations, S.P.S.S, version 12 was used. The Students unpaired 't'-test was performed to determine whether there was any significant difference between the exposed and the control workers.

RESULTS

All the subjects (males, n = 119) were divided into two categories: the control subjects (60) and the exposed battery workers (59). The physical parameters of the control and the exposed male battery workers are presented in [Table/Fig-2]. The age, height, weight and the body surface area of the control and the exposed groups were comparable; no significant differences were noticed. The lung volumes (FVC, FEV_1, and FEV_1/FVC) and the flow rates ($FEF_{25-75\%}$, PEFR) of the control and the exposed male battery workers are presented in [Table/Fig-1]. It was found that the mean values of the lung volumes and flow rates of the control subjects were higher than those of the exposed workers, but there was no statistically significant difference between them.

The duration of the exposure was categorically divided into three groups: up to 10 years (n = 18), 11-20 years (n = 15) and above 20 years (n = 28). The different lung volumes and the flow rates of both the control and the exposed male battery workers according to the duration of the exposure are presented in [Table/Fig-3]. A trend of gradual decrement of the lung function parameters was found in the exposed subjects as the duration of the exposure increased. There was a statistically significant (p value < 0.05) difference between the above 20 years exposure group and the other two exposure groups in all the pulmonary function parameters, but there was no difference between the 11-20 years exposure group and the up to 10 years exposure group.

The respiratory symptoms as reported by the control and the exposed subjects are presented in [Table/Fig-4]. Respiratory symptoms like cough with breathlessness, morning cough, cough throughout the day, andchest tightness were reported. The percentage figures of these symptoms were significantly higher in the exposed subjects (32.75%) as compared to the control subjects (12.65%). Cough with breathlessness was found to be higher among all the symptoms in the exposed as well as the control subjects.

The spirometric assessment of the respiratory function impairments among the exposed workers and control subjects are presented in [Table/Fig-5]. The respiratory impairments of the restrictive, obstructive and the mixed types among the exposed workers as a whole, were much higher (28.60%) as compared to those in the controls (6.40%). According to the category, in exposed workers, the restrictive type of impairment was 5.60%, the obstructive type was 18.50% and the combined type was 4.50%; the corresponding figures in the control subjects were 3.50% restrictive and 2.90% obstructive. No combined type of impairments were found in the control subjects.

DISCUSSION

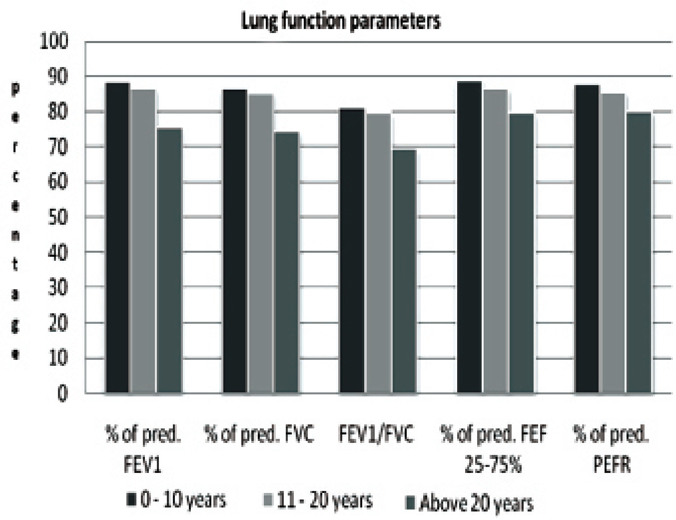
The workers of the battery factory were exposed to different chemical dusts, mainly cadmium. With modernization (proper designing and effective ventilation of the working place), a decline

Parameters	Battery workers (n = 59) (mean ± SD)	Control subjects (n = 60) (mean ± SD*)	Percentage changes	P value
Age (years)	36.63 ± 12.43	35.56 ± 11.45	+ 3.01	NS§
Height (cm)	162.75 ± 5.62	163.24 ± 6.12	- 0.30	NS
Weight (kg)	54.34 ± 7.45	52.45 ± 8.34	+ 3.60	NS
BSA† (m^2)	1.54 ± 0.13	1.53 ± 0.13	+ 0.65	NS
BMI‡	20.12 ± 2.67	19.65 ± 2.78	+ 2.39	NS

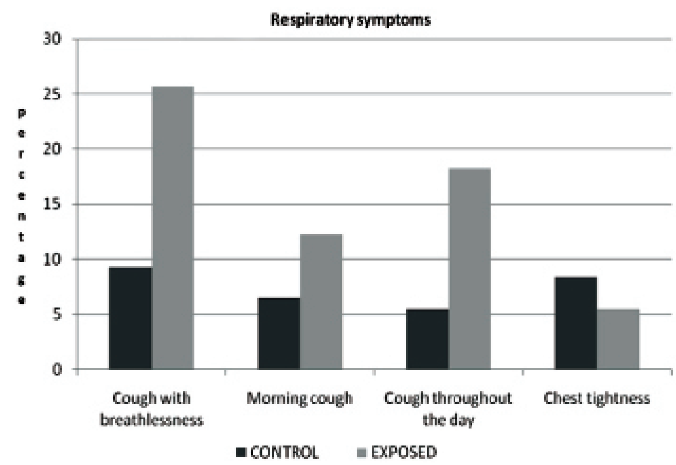
[Table/Fig-1]: Anthropometric and physical parameters of exposed male dry cell battery workers and control male subjects.
*Standard deviation, †Body surface area, ‡Body mass index, §Nonsignificant.

Parameters		Battery workers (n = 59) (mean ± SD*)	Control subjects (n = 60) (mean ± SD)	Percentage changes	P value
FEV_1 (l)	Absolute value	3.36 ± 0.87	3.52 ± 0.85	- 4.54	NS†
	% of pred.	83.69 ± 6.76	85.57 ± 6.89	- 2.20	NS
FVC (l)	Absolute value	3.88 ± 0.78	3.98 ± 0.85	- 2.52	NS
	% of pred.	84.67 ± 8.48	86.62 ± 7.44	- 2.25	NS
FEV_1/FVC		85.23 ± 19.45	87.56 ± 18.34	- 2.66	NS
$FEF_{25-75\%}$ (l/sec)	Absolute value	4.18 ± 1.82	4.68 ± 1.37	- 10.68	NS
	% of pred.	87.42 ± 8.55	89.56 ± 8.43	- 2.39	NS
PEFR (l/min)	Absolute value	493.62 ± 65.45	508.45 ± 53.56	- 2.92	NS
	% of pred.	88.48 ± 9.23	90.35 ± 8.46	- 2.07	NS

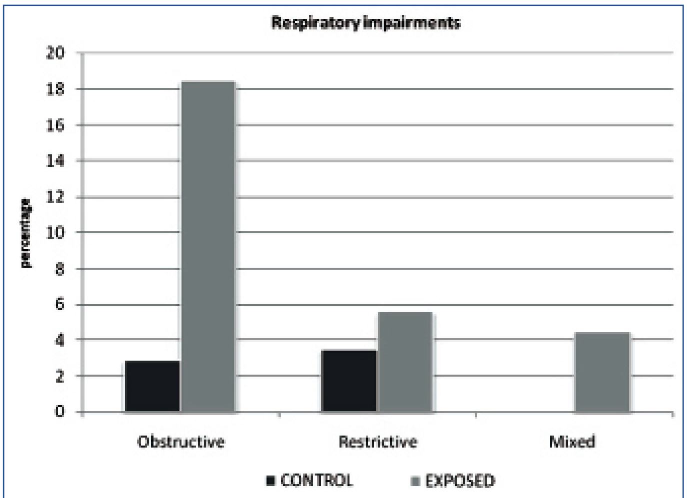
[Table/Fig-2]: Lung volumes and flow rates of exposed male dry cell battery workers and control male subjects.
*Standard deviation, † Nonsignificant.



[Table/Fig-3]: Comparison of lung function parameters of male dry cell battery factory workers according to duration of exposure.



[Table/Fig-4]: Distribution of respiratory symptoms in both control group and exposed male battery workers.



[Table/Fig-5]: Comparison of respiratory impairments of both control group and exposed male battery workers.

of the cadmium dust by 100 to 500 times in the work-room was observed in western countries [2]. In our country, the scenario may not be the same. The most important route of the dust exposure was inhalation. It was found that the contamination by cigarettes or pipe tobacco in the workers could cause an additional inhalation exposure. Cigarettes or pipe tobacco could get contaminated from the workers' hands depending upon their habits, their sweating and their maintenance of personal hygiene. With the release of contaminated cadmium during the burning of tobacco, there could be an increased amount of cadmium in the inhaled tobacco smoke. The smokers generally had higher faecal amounts of cadmium than the nonsmokers [11].

In a study which was done with 16024 workers, it was found that the current smokers had higher mean urinary cadmium/ creatinine levels than the former smokers or non-smokers. The higher levels of urinary cadmium were associated with a significant lower FEV_1 in the current (-2.06%, 95% confidence interval(CI) -2.86 to -1.26 per 1 log increase in urinary cadmium) and formal smokers (-1.95%, 95% CL -2.87 to 1.03), but not in the never smokers (-0.18%, CI -0.60 to 0.24). Similar results were obtained for FVC and FEV_1/FVC [3].

In our study, we excluded smokers, to avoid the direct or indirect smoking related spirometric changes. Among the non-smokers, there was a significant correlation between the air levels of cadmium and the faecal content of cadmium, indicating that in the work places, the cadmium concentrations in the air may also have reflected the general dust contamination of the working areas. There was always an invisible thin layer of dust on all the surfaces (wall, furniture, etc.) in the factory. The workers may have contaminated their clothes, hands and other body surfaces, depending on their personal habits, sweating, etc. Then, cadmium might have entered the body of the workers by inhalation or ingestion through contaminated food. Cadmium oxide dust which is inhaled from air will be deposited in the respiratory tract and a part of the deposited cadmium will be absorbed from the alveoli [12].

In a study on battery workers who were exposed to Manganese (Mn), it was found that the concentrations of Manganese in blood (MnB) and urine (MnU) were significantly higher in the exposed group (MnB 0.81 Vs 0.68 micro grams/ 100ml; MnU 0.84 Vs 0.09 micro gram/ gram creatinine). The prevalence of the respiratory symptoms and the lung function parameters did not differ in the control and the exposed groups [13].

In a study population of 3086 employees in carbon black production plants, it was found that the coughed sputum and the symptoms of chronic bronchitis were associated with the degree of exposure to carbon. The lung function tests also showed a small decrease with respect to an increase in the dust exposure in both smokers and non smokers. Nearly 25% of the CXR showed small opacities of category 0/1 or greater [14].

In the present study, the age, height, weight, body surface area and the body mass index were comparable among the battery workers and the control subjects. In the present study, a reduction in the mean values of lung function parameters, i.e., FVC, FEV_1 and FEV_1/FVC, $FEF_{25-75\%}$, PEFR was noted in the exposed workers as compared to the control subjects, but it was not statistically significant.

Contrary to the findings of Mannino D M, et al. in our study, we found a decline in the spirometric parameters in the dry cell battery workers and this decline showed a definite correlation with the duration of exposure [12]. In smokers, this decline could be even higher. We detected obstructive airway disease (FEV_1/FVC ratio < 70%) in 18.50% workers, though they were asymptomatic, and significantly all had a long history of battery factory exposure (> 20 years).

However, our study population was small (n = 59), and we excluded smokers, those who had a present or past respiratory disease and those with an abnormal X-ray of the chest. So, the actual prevalence of the decrease in the spirometry parameters may have been higher. Further studies are required to evaluate the effect of the dry battery ingredients on the lung functions among factory workers, and to identify the causative factors and the necessary steps to prevent the decline of lung function in the dry cell battery factory workers.

REFERENCES

[1] Langkau JF, Noesges RA. Esophageal burns from battery ingestion. *Am J Emerg Med*. May 1985;3(3):265.
[2] Friberg L. Health hazards in the manufacture of alkaline accumulators with a special reference to chronic cadmium poisoning. *Acta Med. Scand*. 1950;138 (Suppl.):240.
[3] Adamsson E, Piscator M, Nogawa K. Pulmonary and gastrointestinal exposure to cadmium oxide in a battery factory. *Environmental Health Perspectives* 1979;28:219-22.
[4] Ruppel GL. Pulmonary function testing. Trends and techniques. North *Am Resp Care Clin* 1997. p. 155-81.
[5] Hendrick DJ. Smoking, cadmium and emphysema. *Thorax* 2004;59: 184-85.
[6] Miller MR, Crapo R, Hankinson J, Brusasco V, Burgos F, Casaburi R, et al. General considerations for lung function testing. *Eur Respir J* 2005 26:153-61.
[7] Chattopadhayay BP, Alam J. Spirometric function of the ventilatory function in non-smokers and different graded smokers of Calcutta. *Indian J Environ Protec* 1996;14:274-9.
[8] Du Bois D, Du Bois EF. A formula to estimate the approximate surface area if height and weight be known 1916. *Nutrition* 1989;5:303-11.
[9] Chatterjee S, Saha D, Chattopadhayay BP. Pulmonary function studies in healthy non-smoking men of Calcutta. *Ann Hum Biol* 1988;15:365-74.
[10] Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi R, et al. Interpretative strategies for lung function tests.*Eur Respir J* 2005 26:948-68.
[11] Piscator M, Kjellstrom T. Lind B. Contamination of cigarettes and pipe tobacco by cadmium oxide dust. *Lancet II* 1976:587.
[12] Mannino DM, Holguin F, Greves HM, Savage-Brown A, Stock AL, Jones RL. Urinary cadmium levels predict lower lung functions in current and former smokers: data from the Third National Health and Nutrition Examination Survey. *Thorax* 2004;59(3):194-98.
[13] Roles HA, Ghyselen P, Buchet JP, Ceuleman S, Lauwerys RR. Assessment of the permissible exposure level to Manganese in workers who were exposed to Manganese dioxide dust. *Br J Ind Med* 1992 Jan;49(1):2534.
[14] Gardiner K, Trethowan NW, Harrington JN, Rossiter CE, Calvart IA. Respiratory health effects of carbon black: a survey of European carbon black workers. *Br J Ind Med* 1993 Dec; 50(12):1082-96.

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FINANCIAL OR OTHER COMPETING INTERESTS:
None.

Date of Submission: **Oct 21, 2011**
Date of peer review: **Jan 01, 2012**
Date of acceptance: **Jan 17, 2012**
Date of Publishing: **May 01, 2012**