

Effect of Exposure to Cement Dust on Peak Expiratory Flow Rate of Cement Factory Workers

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Abstract

Background: Pollutants exerted from different industries are hazardous for both employees and the environment. Though cement industry is playing a key role in economic growth but is a major source of air pollution. Its exposure affects pulmonary functions due to alteration of structural and functional properties of lung. Peak Expiratory Flow Rate (PEFR) is a simple, less expensive pulmonary function test which can be done by spirometer to detect obstructive changes in the respiratory tract. This study is aimed to assess the effect of cement dust on peak expiratory flow rate of workers, those who are exposed to cement dust directly in cement factory.

Materials and methods: This case control study was conducted in the Department of Physiology, Chittagong Medical College, Chattogram in collaboration with Heidelberg Cement Bangladesh Ltd at Chattogram from January 2018 to December 2018. Total 88 male workers with age ranged from 20 to 45 years were included in this study by consecutive sampling method. Case group workers were selected from those who were working at least two years in direct contact of cement dust and control group were from office workers of same factory those who were not in direct contact of cement. 44 subjects were included in each group. A predesigned data collection form was filled up by the researcher, which contained information regarding general physical status, job history, present and past disease, drug history of workers. Individual's height, weight was measured and BMI was calculated. PEFR was assessed by a portable digital spirometer (Chestgraph HI-101, Japan) in upright sitting posture. After compiling data, statistical analyses were done by using SPSS version Windows 25. Unpaired student's 't' test was done for statistical analysis.

Results: PEFR of Control and Case group was 7.84 ± 2.21 L/sec and 5.73 ± 1.79 L/sec respectively. In this study Case group showed significant reduction of PEFR ($p < 0.001$) compared to Control group workers.

Conclusion: This study result concluded that occupational exposure to cement dust has deleterious effect on lung which is evident by reduced Peak Expiratory Flow Rate (PEFR) of cement exposed workers.

Key words : Cement; Peak expiratory flow rate; Spirometer.

Introduction

Inhalation of air borne agents from work place is a significant source of occupational respiratory diseases.¹ Impairment of membrane structure and mechanical efficiency may be caused by inhalation of pollutants from different industries.² Cement industry is considered as the third largest source of air pollution.³

But cement industry is playing an important role in development of modern world due to rapid urbanization and industrialization.⁴ Many people depend on this industry for employment and business opportunities in this sector.³

Bangladesh has been experiencing production of large amount cement domestically for last the few years.⁴ Accelerated pace of urbanization, various government and non government projects, bridges and flyovers, various commercial and residential building, multi-storied shopping complexes has increased the demand for cement.⁴

But the cement manufacturing projects are considered as major source of air pollution due to different hazardous emissions.⁵ People are exposed to cement during its production, transportation or construction site.⁶ Occupational airborne diseases are considered as one of the important cause of death and disability among people.⁷ Per year more than 2.3 million deaths occur due occupational illnesses.⁶

Cement is a light gray powder which diameter is ranged between 0.05 to 5.0 μm .^{8,9} Two types of cement are available – natural and artificial.³

Artificial cement is known as Portland cement, is a mixture of Calcium Oxide (CaO) (61-67%), Silicon Oxide (SiO₂) (19-23%), Aluminium Oxide

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(Al₂O₃) (3-6%), Ferric Oxide (Fe₂O₃) (2-6%), Magnesium Oxide (MgO) (1-2%), Selenium, Thallium and some other impurities.⁹ Major pollutants contained in cement are Nitrogen oxide (NOx), Sulfur dioxide (SO₂) and Carbon monoxide (CO).³ They may cause throat and nose irritation, lung tissue damage, impairment of oxygen delivery to various organs and tissues.^{3,10} It may also contribute to smog formation in air which create respiratory problems.³

Long term exposure of cement dust may cause varying degree of lung function reduction and respiratory symptoms like dyspnea, chest pain, sneezing, phlegm, wheeze, prolonged and recurrent cough.¹¹ Chronic obstructive lung disease, restrictive lung disease, Pneumoconiosis, bronchitis, sinusitis, bronchial asthma and carcinoma of lung, stomach and colon may also occur in chronic dust exposure.^{1,3,9,12,13}

Cement dust particles may enter into the body through inhalation or swallowing.¹² Severity of lung function impairment depends on size, composition, deposition pattern, exposure duration, individual susceptibility and biological responses by cement in various region of respiratory tract.^{5,14,15}

In developing countries millions of people are engaged in cement industry but most of them are unaware of hazardous effect of cement on human body. So, they work without proper respiratory protective equipment, high quality face mask and appropriate training.¹⁶ Several previous study observed pulmonary functions of cement workers by spirometer to observe the effect of cement on respiratory system.^{11,17-22} Significant reduction of PEFr was observed in their study.^{11,19,23,24} In Bangladesh, no adequate data is available regarding the effect of cement dust on peak expiratory flow rate. So, this study is designed to evaluate the effect of cement dust on pulmonary functions such as peak expiratory flow rate to make awareness and protect the workers from developing chronic respiratory impairment, which may be also helpful for lowering medical costing of the workers and ultimately economic growth of the country.

Materials and methods

This case control study was conducted in Department of Physiology, Chittagong Medical College,

Chattogram with collaboration of Heidelberg Cement Bangladesh Ltd. Chattogram from January 2018 to December 2018 after ethical approval and permission of Chittagong Medical College and cement factory authority. Study subjects were selected from workers of Heidelberg cement factory Ltd at Chattogram. 44 apparently healthy, 20-45 years aged non-smoker male, working 8-10 hr/day for six days/week for more than 2 years in direct contact of cement were selected as Case group. Age and socio economic status matched Control group were taken from office workers of same factory those who were not in direct contact of cement dust. They were explained about the aims, objectives and detail procedure of the study. They were also encouraged for voluntary participation and allowed freedom to withdraw from the study any time. They were also ensured that collected data will be used only for research purpose and informed written consent was taken from each individual.

On the basis of inclusion and exclusion criteria subjects were selected by consecutive sampling method. On the day of data collection information of subjects regarding age, job duration, site and position of work place, use of safety gadget, physical condition, drug history, acute or chronic cardiorespiratory abnormality of subjects was taken. Subjects having history of any respiratory disease, skin rash, chronic cough, fever, acute infection, hypertension, chest deformities, history of major abdominal or thoracic surgery, diabetes, hypertension were excluded from the study. Those who were taking drugs such as bronchodilators, sedative, antitubercular therapy, steroid, beta blocker, chemotherapeutics was also excluded from the study.

Height was measured in feet-inches by plotting a height measuring scale against the wall of the room. Standing straightly on bare foot, from the top of the vertex to the bottom of the foot height was recorded. Weight was measured in kilogram (Kg) by a standard analogue weighing machine on bare foot and avoid excess clothing. Then BMI was calculated by using following formula-

$$\text{BMI} = \frac{\text{Weight in Kg}}{\text{Height in m}^2}$$

General examination was done and blood pressure, pulse, temperature, respiratory rate was recorded. Auscultation of chest was done to exclude any cardiorespiratory abnormality.

For exclusion of diabetes mellitus RBS was measured by glucometer (One touch ultra, USA, AW-061-566-01A) and to exclude anemia Hb% was done instantaneously by Sahli-Adam's acid hematin method with the help of a trained technician.

After analyzing the case record form, selected subjects were underwent spirometry. Prior to spirometry, they were demonstrated clearly and practiced several times. Those who performed perfectly were included as study subject.

For spirometric test subjects were asked to sit upright on a comfortable chair quietly and relaxed for 5 minutes. Then switch of the spirometer was on and information regarding subject's ID, age, height (cm), weight (kg), sex, race was inputted in the device. Disposable card board mouthpiece was used for each individual. After nose clipping, mouthpiece was placed in between the lips of subject.²⁵ They were asked to hold the mouthpiece horizontally in their hand and put the lips tightly around the mouthpiece for good sealing. Then they were asked to inhale as deeply and rapidly as possible and exhale forcefully as possible for possible longest period into the mouthpiece.²⁵ After three attempts, the best of three recordings was taken. Then nose clip was removed and the machine was powered off.²⁵ The readings of spirometry were collected from the tracing of spirometer and PEFR was recorded in data collection form.

Data were analyzed by using SPSS-25 (Statistical Package for the Social Sciences). Between groups comparison of variables were done by unpaired student's 't' test. Categorical data were expressed as frequency and percentages and Chi-square test was done to comparison between two groups. p value <0.05 was accepted as level of significance.

Results

Table I showing demographic characteristics such as education level, salary, marital status and residency of study subjects. Non significant differences ($p > 0.05$) were observed regarding socioeconomic status in both group (Table I). Table II showing mean (\pm SD) of age, height, weight, BMI, Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), respiratory rate of Control group was 37.05 ± 6.52 years, 164.89 ± 4.68 cm, 60.18 ± 3.71 Kg, 22.10 ± 0.88 , 121.59 ± 9.39 mm Hg, 78.41 ± 3.69 mm Hg, 14.91 ± 0.83 breaths/min and among Case group was 37.23 ± 8.29 years, 164.50 ± 3.91 cm, 60.02 ± 3.55 Kg, 22.17 ± 0.73 ,

122.95 ± 11.12 mm Hg, 77.05 ± 5.09 mm Hg, 14.66 ± 0.89 breaths/min respectively. No significant difference ($p > 0.05$) was observed between two groups regarding anthropometric parameters. It indicates subject selection was similar in both group.

Table III showing mean (\pm SD) of PEFR of Control and Case group was 7.84 ± 2.21 L/sec and 5.73 ± 1.79 L/sec respectively. Significant reduction of PEFR ($p < 0.001$) was found in Case group workers comparing Control group (Table III).

Table I : Demographic data of Control and Case group (n=88)

Attributes	Control Group [n=44]	Case Group [n=44]	p value (χ^2 value)
Education level	Graduate	12	0.113 ^{ns} (2.514)
	Undergraduate	32	
Salary (Taka)	Grade-I	28	0.161 ^{ns} (1.965)
	Grade-II	16	
Marital status	Married	36	0.777 ^{ns} (0.080)
	Unmarried	8	
Residency	Resident	27	0.170 ^{ns} (1.886)
	Non-resident	17	

Statistical analysis done by Chi square (χ^2) test. n = number of the subjects, Grade-I=Income (20,000-30,000) taka per month, Grade II=Income (31,000-40,000) taka per month, ns = not significant ($p > 0.05$)

Table I showing no significant difference in socioeconomic status between Control and Case group.

Table II: Age, Height, Weight, BMI, Blood pressure and Respiratory rate in Control and Case group (n=88)

Variables	Control Group [n=44] Mean \pm SD (Range)	Case Group [n=44] Mean \pm SD (Range)	p value (t value)
Age (Years)	37.05 ± 6.52 (22 - 45)	37.23 ± 8.29 (21 - 45)	0.909 ^{ns} (0.114)
Height (cm)	164.89 ± 4.68 (152 - 172)	164.50 ± 3.91 (157 - 172)	0.675 ^{ns} (0.420)
Weight (Kg)	60.18 ± 3.71 (52 - 68)	60.02 ± 3.55 (52 - 68)	0.837 ^{ns} (0.206)
BMI (Kg/m ²)	22.10 ± 0.88 (19.70 - 22.90)	22.17 ± 0.73 (20.10 - 22.90)	0.713 ^{ns} (0.369)
SBP (mmHg)	121.59 ± 9.39 (100 - 130)	122.95 ± 11.12 (90 - 130)	0.536 ^{ns} (0.622)
DBP (mmHg)	78.41 ± 3.69 (70 - 80)	77.05 ± 5.09 (60 - 80)	0.154 ^{ns} (1.437)
Respiratory rate (Breaths/min)	14.91 ± 0.83 (13-16)	14.66 ± 0.89 (13-16)	0.176 ^{ns} (1.364)

Statistical analysis done by Unpaired Student's 't'-test. Data expressed as Mean \pm SD, n = number of the subjects, Figures in parenthesis indicate Range, ns = not significant ($p > 0.05$), BMI = Body Mass Index, SBP = Systolic blood pressure, DBP = Diastolic Blood Pressure.

Table II shows no significant difference in age, height, weight, BMI, SBP, DBP and Respiratory rate between Control and Case group.

Table III: Comparison of PEFR in Control and Case group (n=88)

Variables	Control group [n=44] Mean \pm SD (Range)	Case group [n=44] Mean \pm SD (Range)	p value (t value)
PEFR (Liter/sec)	7.84 \pm 2.21 (3.04 – 12.25)	5.73 \pm 1.79 (2.20 – 8.50)	<0.001** (4.91)

Statistical analysis done by Unpaired Student's 't'-test. Data expressed as Mean \pm SD, n = number of the subjects, PEFR = Peak Expiratory Flow Rate. **= statistically significant test ($p < 0.001$)

Table III shows significant reduction of PEFR in Case group than that of the Control group ($p < 0.001$).

Discussion

In this study, no significant difference was observed between control and case group workers in respect of sociodemographic characteristics, age, height, weight, BMI, blood pressure and respiratory rate. It indicates subject selection was similar in both group.

PEFR showed significant reduction among case group workers in comparison to control group workers. This study finding simulates with some previous studies done by other researchers.^{8,11,17,19,24} As cement dust particle is within respirable range, it easily penetrates respiratory zone.¹⁷ Its accumulation in respiratory tract may cause lung irritation and inflammatory reaction resulting production of mucus and exudate.^{16,17,26,27}

It was supposed that, particles between 0.5 μ to 3 μ reach easily to the interior of the lung.¹ As a result, accumulation and consolidation of mucous that lead to narrowing of airway, lung fibrosis and other complications.^{1,17} So, lung function parameters reduced.¹⁷

Occupational health risk influenced by some factors like inadequate dust control system by the factory, overtime duty, improper and irregular use of Personal Protective Equipment (PPE) duration of dust exposure, size, concentration, deposition pattern and chemical composition of dust particles.^{5,8,14,16,19,20} Though the dust level were not measured by the researcher but the information supplied by the factory author was that the Suspended Particulate Matter (SPM) was 230 $\mu\text{g}/\text{m}^3$ in that factory. But in Bangladesh the SPM level should be below 200 $\mu\text{g}/\text{m}^3$ according to ERC'1997.²⁸ So, the SPM was slightly more than the recommended level for our country.

It was observed that the workers were using PPE during their working hour, but the face mask used by them were non medicated cotton face mask. So, the reason behind reduction of PEFR among case group workers may be due to their inappropriate and interrupted use of poor quality face-mask or inadequate dust filtration system by the factory.

As X-ray chest of the workers were not done, so it was not confirmed that the study subjects had either obstructive or restrictive type lung function impairment.

Limitations

Though optimal care had been tried by the researcher in every steps of the study but there were some limitations.

- Sample size was small and subjects were selected from a selective area.
- Sampling was done by consecutive sampling, so chance of bias.
- Level of dust exposure was not measured.
- Chest X-ray was not done.

Conclusion

It can be concluded that cement dust exposure significantly reduced peak expiratory flow rate. Though exact mechanism is unknown regarding this reduction but it may be due to improper dust filtration system or ineffective face mask used by the workers and lack of knowledge about the health risk related to cement.

Recommendation

If further study can be done with large sample size, measuring individual dust exposure level including subjects from more area with doing X-ray

chest may provide a deeper information. Factory authority can be advised for pre-employment and periodical health checkup at least once in a year and to provide training about proper use of PPE to the workers and limiting the dust level by adequate dust filtration system in the working area to reduce the complication related to cement dust.

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Contribution of authors

MA- Conception, design, acquisition of data, interpretation of data, drafting and final approval.

NN- Conception, data collection, manuscript writing & final approval.

MB- Conception, design, critical revision & final approval.

SA- Conception, manuscript writing, critical revision & final approval.

AD- Design, data collection, data analysis & final approval.

Disclosure

All the authors declared no competing interests.

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