

Cotton dust exposure: Analysis of pulmonary function and respiratory symptoms

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ABSTRACT

Background: Cotton industry workers are exposed to various hazards in the different departments of textile factories. The major health problems associated with cotton dust are respiratory problems, byssinosis, bronchitis and asthma. **Objective:** To study the effect of cotton dust exposure on pulmonary function and respiratory symptoms. **Settings and Design:** This cross-sectional observational study was conducted at cotton mill in the Ahmedabad city. **Materials and Methods:** One hundred cotton mill workers of the weaving and spinning area participated in this study while 100 age- and gender-matched male subjects living in the residential area served as the control group. A questionnaire was used to inquire about respiratory symptoms and spirometry was done in both the groups. **Statistical Analysis Used:** Student's *t*-test was used to find the difference between spirometric parameters, and Chi-square test was used to find the difference between respiratory symptoms. **Results:** Respiratory symptoms were statistically significantly more common in the cotton mill workers compared to control group. Cotton mill workers group also showed significant ($P < 0.0001$) decrease in forced expiratory volume in 1 s (FEV1), ratio of FEV1 and forced vital capacity (FVC) and peak expiratory flow rate, and no significant difference of FVC between groups. There was an association of duration of exposure and symptoms with spirometric abnormality. **Conclusion:** Cotton mill workers showed a significant decrease in spirometric parameters and increase in respiratory symptoms. As the duration of exposure and symptoms increased, spirometric abnormality increased.

KEY WORDS: Cotton dust, pulmonary function, respiratory symptoms

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INTRODUCTION

Cotton dust is defined as dust generated into the atmosphere as a result of processing the cotton fibers combined with any naturally occurring materials such as stems, leaves, bracts, and inorganic matter which may have accumulated on the cotton fibers during growing and harvesting period.^[1]

According to occupational safety and health administration, the permissible exposure limit for cotton dust is 200 μg per

cubic meter of lint-free respirable dust averaged over an 8-h period in yarn manufacturing; 750 μg per cubic meter of lint-free respirable dust over an 8-h period of slashing and weaving; and 500 μg per cubic meter of lint-free respirable dust over an 8-h period in waste houses and yarn manufacturing where exposure to lower grade washed cotton occurs.^[2] The National Institute of Occupational Safety and Health recommends that exposure to cotton dust be reduced to lowest feasible limits which is defined as being exposure limit $<200 \mu\text{g}/\text{m}^3$.^[3]

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Cotton dust is classified according to size of particle-like trash (above 50 μm in diameter), dust (50–500 μm), micro dust (15–50 μm), and breathable dust (15 μm). Particles with aerodynamic diameter $\leq 2.5 \mu\text{m}$ and $\geq 0.1 \mu\text{m}$ are called fine particulates and are sedimented out in the gas-exchange region of the lung, where air movement is slow. These particles tend to be remained in the respiratory bronchioles within the central part of the acinus.^[4]

Occupational chronic obstructive pulmonary disease (COPD) is defined as COPD where there has been a material contribution made to its development, or severity, by inhaled workplace agent.^[5] Occupational lung disease is a major problem in workers working in various textile factories. The cotton mill workers work in various departments of cotton mill like opening, picking, combing, weaving, slashing, and spinning during which exposure to raw cotton dust occurs. The acute exposure to cotton dust can produce feeling of chest tightness, coughing, wheezing, phlegm, and breathing difficulty. Long-term exposure to cotton dust may result in excessive chronic annual loss in forced expiratory volume in 1 s (FEV₁), and in higher proportions of persistent respiratory symptoms.^[6] Apart from respiratory symptoms and lung impairment, airway allergy and positive skin reaction were also noted in persons exposed to cotton dust.^[7]

Numerous studies have been done to investigate both acute and long-term exposure of cotton dust. Various measures can be done to reduce the exposure of cotton dust such as dust control, engineering control, and use of personal protective equipment. The effectiveness of these measures to prevent lung dysfunction is not known. Not a single study has mentioned the use of personal protective equipment by cotton mill workers. The present study was done to analyze effect of exposure of cotton dust on pulmonary function and respiratory symptoms. All the workers in the study used face mask during working hours, so the study would provide additional information about whether the use of personal protective equipment like face mask is sufficient to prevent deterioration in lung function.

MATERIALS AND METHODS

Study population

Ethical clearance for the present study was taken from the Institutional Ethics Committee. A cross-sectional study was conducted in a cotton mill of Ahmedabad city. One hundred male nonsmoking cotton mill workers, working in the spinning and weaving area of the mill for at least 1-year duration in the age group of 20–50 were included in the study. The cotton mill workers had their duties 8 h/day for 6 days in a week. All the workers used face mask during working hours. The type of mask was reusable cotton cloth mask. As a control group, 100 age- and gender-matched

male subjects living in the residential area, without any history of occupational or environmental exposure, were selected for the study. Subjects having history of cardiac and respiratory diseases, history of smoking and/or tobacco chewing, chest and abdominal surgery, and neuromuscular and/or musculoskeletal abnormalities were excluded from the study.

Questionnaire

All subjects were first interviewed by a questionnaire. It included questions on personal information, respiratory symptoms, and work history. Personal information included name, age, and history of smoking and tobacco chewing. Respiratory symptoms such as dyspnea, cough, and chest tightness were documented. Symptoms were considered to be work-related if they improved over a weekend or holiday or if employees reported them to be provoked by contact with cotton dust. Work history included questions covering all the details of present and past employment, history of job-related occupational exposure, job responsibilities, working time, working area, duration of employment, and the use of protective equipment during work.

Spirometry

Spirometry was done in the sitting position for all the subjects with the computerized spirometer HELIOS 401 machine. Age, height, and weight of the subjects were measured and entered in the software before performing the test. The spirometer gives two values; one is actual, and the other is expected. Spirometric parameters studied were forced vital capacity (FVC), FEV₁, ratio of FEV₁ and FVC, and peak expiratory flow rate (PEFR).

The Helios software, Haryana, India (Recorders and medicare systems private limited (RMS)) calculates the expected values for male adults, using the following set of prediction equations.

$$\begin{aligned} \text{FVC (L)} &= (0.0678 \times [\text{Height}] - 0.0147 \times [\text{Age}] - 6.05) \\ \text{FEV}_1 \text{ (L)} &= (0.0499 \times [\text{Height}] - 0.0211 \times [\text{Age}] - 3.84) \\ \text{PEFR (L/S)} &= (0.095 \times [\text{Height}] - 0.0209 \times [\text{Age}] - 5.77) \end{aligned}$$

Spirometry was done according to the guidelines of American thoracic society.^[8] FVC maneuver was properly explained to the subjects. They were asked to do three efforts. The best value of three was recorded. They were given appropriate rest between each trial. To ensure validity, each subject performed a minimum of three acceptable FVC maneuver while for reliability, largest FVC, and the second largest FVC from the acceptable trials was kept in the range of <0.150 liters.

Outcome measures

Respiratory symptoms such as dyspnea, cough, and chest tightness, and spirometric parameters such as FEV₁, FVC, FEV₁/FVC, and PEFR were used as an outcome measures.

Statistical analysis

The evaluation of respiratory symptoms and spirometry was done in all subjects. Data were analyzed by GraphPad Prism 5.01 software (Graphpad prism). The spirometry data and baseline characteristics of the subjects were compared using unpaired *t*-test.

RESULTS

Table 1 shows baseline characteristics of the subjects such as age, height, weight, and body mass index (BMI). (calculated by dividing subject's weight in kilogram and height in square meter). All subjects were similar in baseline characteristics. Table 2 shows predicted and observed values of spirometric parameters of control group. The observed value of all the spirometric parameters was statistically significant compared to predicted values. It shows the good lung function in this group. Table 3 shows predicted and observed values of spirometric parameters of cotton mill workers. The observed values of spirometric parameters, such as FEV1, FEV1/FVC, and PEFr, were significantly decreased in cotton mill workers compared to predicted values. Table 4 and Figures 1 and 2 show the comparison of spirometric parameters between groups. Spirometric parameters such as FEV1, FEV1/FVC, and PEFr were significantly decreased in cotton mill workers compared to control group. There was

Table 1: Baseline characteristics of the subjects

| | Mean±SD | | P |
|--------------------------|---------------------|------------------|------|
| | Cotton mill workers | Control subjects | |
| Age (years) | 38.56±8.47 | 37.50±8.02 | 0.36 |
| Height (cm) | 170.4±5.09 | 169.5±7.48 | 0.28 |
| Weight (kg) | 66.20±6.54 | 65.38±9.41 | 0.47 |
| BMI (kg/m ²) | 22.83±0.25 | 22.80±0.32 | 0.93 |

P>0.05=Not significant, *P*<0.05=Statistically significant. SD: Standard deviation, BMI: Body mass index

Table 2: Spirometry parameters of control group

| Parameter | Mean±SD | | P |
|------------|------------|------------|---------|
| | Predicted | Observed | |
| FVC (L) | 3.44±0.33 | 3.58±0.55 | <0.0001 |
| FEV1 (L) | 2.84±0.32 | 3.13±0.39 | <0.0001 |
| FEV1/FVC% | 82.49±2.68 | 85.11±6.15 | <0.0001 |
| PEFR (L/S) | 9.57±0.07 | 9.83±0.07 | 0.40 |

P>0.05=Not significant, *P*<0.05=Statistically significant. FVC: Forced vital capacity, FEV1: Forced expiratory volume in 1 s, FEV1/FVC: Forced expiratory volume in 1 s/forced vital capacity, PEFr: Peak expiratory flow rate, SD: Standard deviation

Table 3: Spirometry parameters of cotton mill workers

| Parameter | Mean±SD | | P |
|------------|------------|------------|---------|
| | Predicted | Observed | |
| FVC (L) | 3.48±0.31 | 3.49±0.55 | 0.91 |
| FEV1 (L) | 2.86±0.31 | 2.70±0.05 | 0.009 |
| FEV1/FVC% | 82.08±2.53 | 79.99±6.02 | 0.001 |
| PEFR (L/S) | 9.65±0.05 | 8.43±0.06 | <0.0001 |

P>0.05=Not significant, *P*<0.05=Statistically significant. FVC: Forced vital capacity, FEV1: Forced expiratory volume in 1 s, FEV1/FVC: Forced expiratory volume in 1 s/forced vital capacity, PEFr: Peak expiratory flow rate, SD: Standard deviation

no significant difference of FVC between groups because of obstructive nature of lung impairment. Table 5 shows comparison of respiratory symptoms between groups. Out of 100 subjects in experimental group, 85 subjects complained breathlessness, 65 subjects complained cough, and thirty subjects complained chest tightness. In the control group, only five subjects complained breathlessness and ten subjects complained cough and nobody complained chest tightness. Chi-square test was used to find the difference between respiratory symptoms, and statistical significant difference (*P* < 0.0001) was found between groups. Cotton mill workers were divided according to the presence and absence of symptoms as asymptomatic workers and symptomatic workers. Out of 100 cotton mill workers, 15 subjects were asymptomatic, and 85 subjects were symptomatic. Normal spirometry was present in 11 asymptomatic workers and 19 symptomatic workers. Abnormal spirometry was present in four asymptomatic workers and 66 symptomatic workers. Table 6 and Figure 3 show association between spirometry result according to the presence or absence of symptoms in cotton mill workers. Chi-square test was statistically significant (*P* < 0.0001), and it shows that spirometric abnormality was more prevalent in symptomatic workers. According to the duration of exposure, cotton mill workers were divided as ≤5 years of exposure and >5 years of exposure. Table 7 and Figure 4 show association between spirometry results according to the duration of exposure. Chi-square test shows statistically

Table 4: Comparison of Spirometric parameters between cotton mill workers and control subjects

| Parameters | Mean±SD | | P |
|------------|---------------------|------------------|---------|
| | Cotton mill workers | Control subjects | |
| FVC (L) | 3.49±0.55 | 3.58±0.55 | 0.23 |
| FEV1 (L) | 2.70±0.05 | 3.13±0.39 | <0.0001 |
| FEV1/FVC% | 79.99±6.02 | 85.61±6.15 | <0.0001 |
| PEFR (L/S) | 8.43±0.06 | 9.83±0.07 | <0.0001 |

P>0.05=Not significant, *P*<0.05=Statistically significant. FVC: Forced vital capacity, FEV1: Forced expiratory volume in 1 s, FEV1/FVC: Forced expiratory volume in 1 s/forced vital capacity, PEFr: Peak expiratory flow rate, SD: Standard deviation

Table 5: Comparison of respiratory symptoms between groups

| Respiratory symptoms | Cotton mill workers | | Control subjects | | P |
|----------------------|---------------------|--------|------------------|--------|--------|
| | Present | Absent | Present | Absent | |
| Breathlessness | 85 | 15 | 5 | 95 | 0.0001 |
| Cough | 65 | 35 | 10 | 90 | 0.0001 |
| Chest tightness | 30 | 70 | 0 | 100 | 0.0001 |

P<0.05=Statistically significant

Table 6: Chi-square test to find association of spirometry according to presence or absence of symptoms

| | Cotton mill workers | | Total | P |
|---------------------|---------------------|-------------|-------|---------|
| | Asymptomatic | Symptomatic | | |
| Normal spirometry | 11 | 19 | 30 | <0.0001 |
| Abnormal spirometry | 4 | 66 | 70 | |
| Total | 15 | 85 | 100 | |

P<0.05=Statistically significant

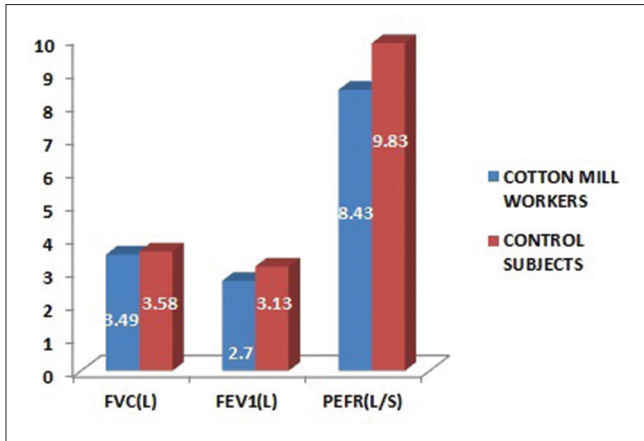


Figure 1: Comparison of observed mean values of forced vital capacity, forced expiratory volume in 1 s and peak expiratory flow rate

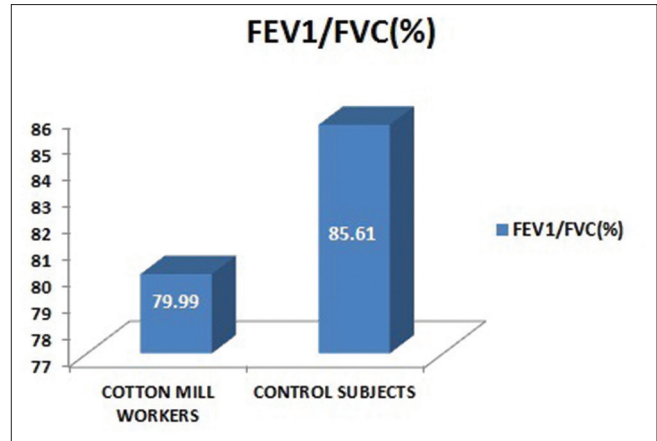


Figure 2: Comparison of observed mean values of forced expiratory volume in 1 s/forced vital capacity

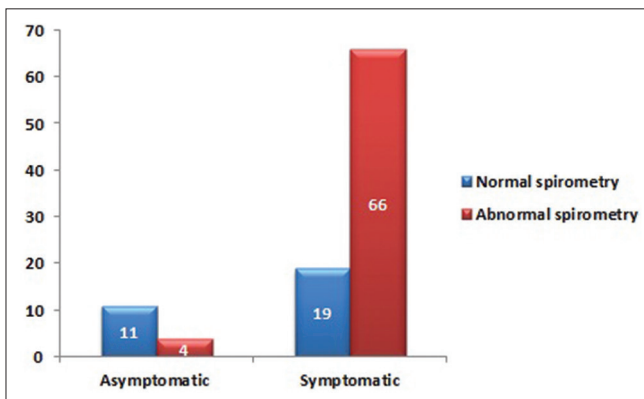


Figure 3: Spirometry results in asymptomatic and symptomatic workers

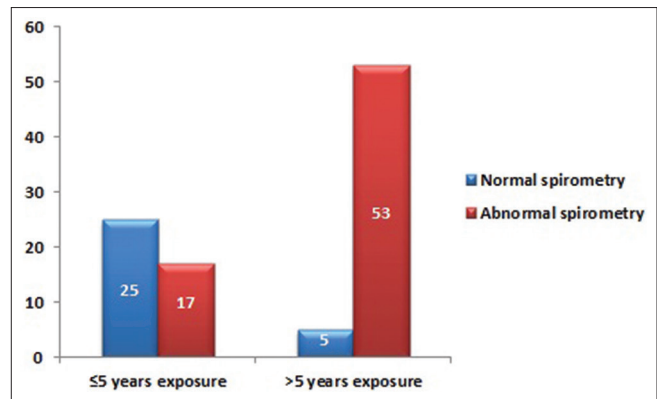


Figure 4: Spirometry results according to duration of exposure

significant association between spirometric abnormality and duration of exposure ($P < 0.0001$). It shows that as the duration of exposure increased, spirometric abnormality increased. Table 8 shows correlation between duration of exposure and age calculated using spearman correlation test. There was a positive correlation between age and duration of exposure.

DISCUSSION

The aim of the present study was to assess the effect of cotton dust exposure on pulmonary function and respiratory symptoms in cotton mill workers. The result of the present study shows that the complaints of respiratory symptoms such as breathlessness, cough, and chest tightness were more in cotton mill workers compared to control subjects. The findings of the study show that spirometric parameters such as FEV1, FEV1/FVC, and PEFr were significantly decreased in cotton mill workers compared to control subjects. There was no significant difference of FVC between groups. This suggests the obstructive type of lung function abnormality in cotton mill workers. Similar results have been observed in other study.^[9]

Table 7: Chi-square test to find association between spirometry according to duration of exposure

| | Cotton mill workers | | Total | P |
|---------------------|---------------------|-------------------|-------|---------|
| | ≤5 years exposure | >5 years exposure | | |
| Normal spirometry | 25 | 5 | 30 | <0.0001 |
| Abnormal spirometry | 17 | 53 | 70 | |
| Total | 42 | 58 | 100 | |

$P < 0.05$ = Statistically significant

Table 8: Correlation between duration of exposure and age

| Variables | Mean±SD | Correlation coefficient | P |
|------------------------------|------------|-------------------------|---------|
| Age (years) | 38.56±8.47 | 0.5941 | <0.0001 |
| Duration of exposure (years) | 8.85±0.85 | | |

$P < 0.05$ = Statistically significant. SD: Standard deviation

The findings of the present study were similar to the study of Mansouri *et al.* They found that long-term exposure to cotton dust is associated with obstructive disease that increases with the duration of exposure. They also performed chest radiography and high-resolution computed tomography scan and found bronchial wall thickening and air trapping, respectively.^[10]

Nagoda *et al.* found that complaints of respiratory symptoms such as cough, phlegm production, rhinitis, wheezing, chest pain, and breathlessness were higher in the exposed textile workers compared to unexposed workers. Exposed worker has a higher frequency of symptoms as well as lower FVC, FEV1, and PEFr than unexposed workers.^[11]

Mohammadien *et al.* found that respiratory symptoms such as cough, expectoration, wheezing, and shortness of breath, were higher among exposed flour mill workers as compared to unexposed. Furthermore, significant decrements in the pulmonary function of exposed subjects were noted.^[12] Altin *et al.* found that complaints of chest tightness, chronic cough, and wheezing in cotton industry workers.^[13]

Wang *et al.* found that chronic bronchitis, cough, and dyspnea were more common and persistent in the cotton group than in the silk group. They found that chronic exposure to cotton dust is related to both work specific and nonspecific respiratory symptoms.^[14] A study of Thiwari *et al.* shows that respiratory morbidity was higher in cotton textile mill workers compared to unexposed comparison group. They found that age >30 years, dust exposure, duration of exposure >10 years, and smoking were significant risk factors for respiratory morbidity.^[15]

The result of the study shows that spirometric abnormality was more prevalent in symptomatic workers compared to asymptomatic workers and those having duration of exposure >5 years. There was a positive correlation between duration of exposure and age in cotton mill workers. Hence, along with occupational exposure, aging can also be a factor in obstructive lung pathology as aging cause decrease in FEV1/FVC ratio.^[16]

Mechanism of lung function abnormality

Dust present during the handling and processing of cotton is considered cotton dust. This dust is a complex mixture of components which may include ground-up plant matter, cotton fiber, bacteria, fungi soil, or pesticides. It may also include other contaminants that have accumulated during the growing, harvesting, and subsequent processing or during storage periods.

Occupational exposure to cotton dust can induce acute airway responses such as byssinosis. Byssinosis is characterized by feeling of shortness of breath and chest tightness on the 1st day of the working week. There may be increased cough and phlegm production. In the early stages of byssinosis, these symptoms subside by the end of the workday and reoccur on Monday morning, after being away from the dust for a period. As the length of exposure increases over the working years of the employee, symptoms of the chest tightness and shortness of breath occur more frequently, and on workdays other than on the 1st day of the workweek. It is believed that the degree or severity of response for individuals with symptoms of byssinosis is related to the dust level in the workplace. The beginning steps in yarn preparation generally produce more dust. Therefore, the closer to the beginning of the process,

the higher will be the dust level, and the more likely the pulmonary reaction or response for some workers.^[17]

Suryakar *et al.* found that oxidative stress may contribute to respiratory disorders in cotton mill workers. As duration of exposure is increased, the effect was enhanced. Long-term exposure to cotton dust results in macrophage/neutrophil migration into the airspaces which generate reactive oxygen species production by opsonization.^[18] According to Lai and Christiani, organic dust exposure in the textile industry leads to obstructive lung disease that has features of both asthma and COPD. An inversion of the pulmonary macrophage: Dendritic cell ratio may be a mechanistic explanation for persistent inflammation and obstructive lung disease seen in endotoxin-related textile exposures. One study showed that the prevalence of respiratory symptoms and byssinosis being higher in smokers than nonsmokers.^[19] Hence, smoking was found to have an additive effect on cotton dust exposure. In the present study, smokers and ex-smokers were excluded from the study group to find the effect of cotton dust exposure on respiratory health.

There were some limitations of the study. Cross shift spirometry and postbronchodilator spirometry had not been done in study group. Apart from spirometry, other pulmonary function tests were not done. Since textile dust-related occupational disease has characteristic of both asthma and COPD,^[20] future study by adding postbronchodilator spirometry can be done to know whether asthma or COPD is present.

CONCLUSION

Our study shows that respiratory symptoms and pulmonary function abnormalities are seen in cotton workers compared to matched controls. The study shows that as the duration of exposure and symptoms increased, spirometric abnormality increased. Despite of the use of face mask, lung function abnormality was present in cotton mill workers. This suggests that more aggressive measures must be taken in the workplace. Sampling of the workplace must be done at regular intervals. Regular medical check-up of all cotton mill workers should be done to prevent the harmful respiratory effect of cotton dust exposure on lung function.

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Conflicts of interest

There are no conflicts of interest.

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