

Comparative study of pulmonary function in human beings exposed to cotton fiber and non-exposed human beings

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Abstract

Introduction: Byssinosis is a breathing disorder that occurs in some individuals with exposure to raw cotton dust; and also in people who work in flax or hemp dust. It is a worldwide and popular occupational disease. Characteristically, workers exhibit shortness of breath and feeling of chest tightness when returning to work after a holiday. Pulmonary function testing (PFT) is important for early identification of workers experiencing breathing problem that may be related to their work place.

Aim: To bring to light the importance of health among the daily wage earners like the cotton workers to avoid sickness and also the employers to decrease the casualties and labour hours.

Materials and Methods: This is a comparative study which was conducted on human male and female subjects comprising of 150 apparently healthy cotton dust workers of ages ranging from 20-30 (Group-I), 30-40 (Group-II) and 40-50 (Group-III) years and an equal number of healthy human beings of same age not exposed to cotton dust. Pulmonary function tests (PFT) namely Forced vital capacity (FVC), Forced expiratory volume in one second (FEV1), Forced expiratory flow (FEF25-75%) and Forced expiratory volume percentage (FEV1 %) were assessed by computerized spirometry. Statistical comparison was done by using the student t-test.

Results: There is a significant decrease in pulmonary function tests FVC, FEV1, FEF 25-75%, FEV1% in human beings exposed to cotton fiber when compared to controls.

Keywords: Byssinosis, FVC, FEV1, FEF 25-75%, FEV1%, Spirometry.

Introduction

Cotton is used to make a number of textile products. The largest exporters of raw cotton are the United States and Africa. Textile manufacturing however had moved to developing nations in Eastern and South Asia, such as China and India, most of the production consumed by their respective textile industries. Byssinosis is a term taken from a Greek word meaning white thread.^{1,2} It is a breathing disorder that occurs in some individuals with exposure to raw cotton dust; and also in people who work in flax or hemp dust.¹ It is a worldwide and popular occupational disease. Characteristically, workers exhibit shortness of breath and feeling of chest tightness when returning to work after a holiday. There may be increased cough and phlegm production. In the early stages of byssinosis these symptoms subside by the end of the work day and recur Monday morning after being away from the dust for a period of time.³ The mechanisms of the reversible obstruction of this disease are as yet unclear, but may involve inhalation of bacterial endotoxin (Rylander et al; 1984).⁴ and the release of mediators such as histamine (Ainsworth et al; 1979). Cotton dust is defined as the dust present in the air which may contain a mixture of contaminants such as ground-up plant matter, fiber, bacteria, fungi, soil, pesticides and non-cotton plant matter. The invisible small dust particles enter into the alveoli of the lung through inhalation. The alveoli are in close contact with the blood that flows in to the lungs. The dust particles get accumulated in the lymph and it damages the alveoli and reduces the capacity to retain

oxygen. As the cotton dust accumulates, the worker develops a brown lung and suffers from byssinosis. As the length of exposure increases over the working years of employee, symptoms of chest tightness and shortness of breath occur more frequently on working days other than on the first day of the work week. Pulmonary function testing (PFT) is important for early identification of workers experiencing breathing problem that may be related to their work place. (US department of Health and human Services).⁵

The mean prevalence of byssinosis in the blow section was 29.62%, the highest found in the carding 37.83%⁶ Different work areas for cotton dust exposure include Blowing, Carding, Drawing, Roving, Twisting, Ring frame, Preparatory and weaving section.

Materials and Methods

The present study was a comparative study conducted on human male and female subjects comprising of 150 apparently healthy cotton dust workers of ages ranging from 20-30 (Group-I), 30-40 (Group-II) and 40-50 (Group-III) years and an equal number of healthy human beings of same age not exposed to cotton dust.

Inclusion criteria for selection of non-exposed control group are based on the fact that they have not worked in cotton dust even once in their life time.

Exclusion criteria from the study if they had signs, symptoms, history of any respiratory, cardiovascular, neurological, renal, hepatic, or gastrointestinal diseases.

All the subjects in the study were nonsmokers, all were informed about test protocol and their written consent was obtained. Ethical committee approval was taken. All the subjects are apparently normal and mentally sound. Height, weight and Hemoglobin estimation of the subject of both groups were recorded. A thorough clinical examination did not reveal any abnormality. All were instructed to attend laboratory after taking light breakfast and were examined between 8 A.M. and 12 Noon. The study was conducted in the pulmonary laboratory of department of tuberculosis and chest diseases, at Government Fever Hospital, Guntur. Lung function tests of the particular study were done using Computerized Spirometer model no "SPIRO 232" P.K. Morgan Medical Ltd.⁷

Study Protocol: The subjects were instructed to wear free clothing and were asked to empty the bladder just before the test was undertaken. Each subject was thoroughly educated to perform the test on the Computerized Spirometer and advised to be calm and quite without any hesitation. Before the test was performed on the subject the investigator demonstrated the test thus enabling the subject to perform the test perfectly in the same way as was done by the investigator. The subject was asked to stand in front of the spirometer and was asked to open his mouth. The mouth piece of the spirometer was introduced into his mouth and he was asked to close the lips around the mouth piece tightly. His nostrils were pinched with nasal clip. The subject was asked to take normal respirations three times consecutively. Then he was instructed to take a deep inspiration of a minimum period of 3 to 4 times.⁸ Immediately after the deep inspiration he was asked to blow out the air as fast as possible into the mouth piece. Soon after this he was asked to take a deep or maximal inspiration, it was ensured that the inspiration was full and unhurried and the expiration once begun was continued without pause. The results were noticed from the computer and were shown in tables. The results taken from the computerized spirometer, the following lung functional test parameters were chosen:

1. Forced vital capacity (FVC):- This is the volume of the air that can be expired force fully and maximally after taking a deep and maximal inspiration. Normal value - 3.5-5.5 liters.
2. Forced expiratory volume in 1st second (FEV1) It is the amount of air that can be expired forcefully and maximally in the 1st second after a maximal inspiration.⁹ Normal values 80%-85% or 4-4.5 liters.
3. Peak expiratory flow rate (PEFR):- It is the amount of air that can be blown out of fully inflated lungs as rapidly as possible. Normal Values 6-15 liters/sec. In adults is 400 liters/ min.
4. FEF (25-75%) forced expiratory flow: This is the average expiratory flow rate during the middle 50% of vital capacity. Forced expiratory flow between 25% to 75% of the vital capacity is called the maximal mid expiratory flow. Normal = 5.21-6 liters.

Statistical Analysis

Data are reported as mean and standard deviation (+SD). Means are compared between two groups by t test. p-value of < 0.05 was considered statistically significant.

Results

The forced expiratory volume in the 1st second (FEV1) in the exposed cotton dust workers of 20-30 years of age (group 1) males, 30-40 years of age (group 2) males, 40-50 years of age (group 3) males were compared with the non-exposed of the same age group males, found significantly reduced by 25.51% (P<0.001), 23.98% (P<0.001) and 25.64% (P<0.001) respectively.

The forced vital capacity (FVC) in the exposed cotton dust workers of 20-30 years of age (group 1) males, 30-40 years of age (group 2) males and 40-50 years of age (group 3) males were compared with the non-exposed of the same age group males was found significantly reduced by 20.7% (P<0.001), 14.95% (P<0.001) and 15.82% (P<0.001) respectively.

The peak expiratory flow rate (PEFR) in the exposed cotton dust workers of 20-30 years of age (group 1) males, 30-40 years of age (group 2) males and 40-50 years of age (group 3) males were compared with the non-exposed of the same age group males was significantly reduced by 41.05% (P<0.001), 75.3% (P<0.001) and 74.15% (P<0.001) respectively.

The forced expiratory flow (FEF 25-75%) in the exposed cotton dust workers of 20-30 years of age (group 1) males, 30-40 years of age (group 2) males and 40-50 years of age (group 3) males were compared with the non-exposed of the same age group males was significantly reduced by 21.9% (P<0.001), 62% (P<0.001) and 62.46% (P<0.001) respectively.

The forced expiratory volume in the 1st second (FEV1) in the exposed cotton dust workers of 20-30 years of age (group 1) females, 30-40 years of age (group 2) females and 40-50 years of age (group 3) females were compared with the non-exposed of the same age group females was significantly reduced by 17.7% (P<0.001), 15.18% (P<0.001) and 14.3% (P<0.001) respectively.

The forced vital capacity (FVC) in the exposed cotton dust workers of 20-30 years of age (group 1) females, 30-40 years of age (group 2) females and 40-50 years of age (group 3) females were compared with the non-exposed of the same age group females was significantly reduced by 34.6% (P<0.002), 2.8% (P<0.01) and 3.85% (P<0.004) respectively.

The peak expiratory flow rate (PEFR) in the exposed cotton dust workers of 20-30 years of age (group 1) females, 30-40 years of age (group 2) females and 40-50 years of age (group 3) females were compared with the non-exposed of the same age group females was significantly reduced by 5.3% (P<0.001), 6.45% (P<0.001) and 4.8% (P<0.001) respectively.

The forced expiratory flow (FEF 25-75%) in the exposed cotton dust workers of 20-30 years of age (group 1) females, 30-40 years of age (group 2) females and 40-50

years of age (group 3) females were compared with the non-exposed of the same age group females was significantly reduced by 18% ($P < 0.001$), 11.9% ($P < 0.001$) and 13.5% ($P < 0.001$) respectively.

Discussion

The reduction of FEV1 and FVC in cotton dust workers was in agreement with the work of E. Neil Schacter, Mary C Kapp et al.¹⁰ The greater annual declines in FEV1 and FVC is also consistent with the study of X-R Wang, H-X Zhang et al. The large acute decrements in FEV1 observed in both the male and female cotton workers are also consistent with our study.¹¹

The study of R.Mc.L. Niven, A.M Fletcher et al showed a decrement in lung function in the intra cotton group compared with controls which is consistent with our study.¹² A symptomatic worker is expected to lose FEV1 at a rate between 8 and 20 ml / year more than the asymptomatic worker.

Present study was also consistent with the study of David. C. Christiani, X-R Wang et al which states that cotton workers had small but significantly greater adjusted annual declines in FEV1 and FVC than the silk workers. Years worked in cotton mills, high level of exposure to endotoxin were found to be significant determinants of longitudinal changes in FEV1.¹¹

Pulmonary function studies by Saadat Ali Khan in cotton ginners in Pakistan showed a significant decline in FVC, FEV1 and PEFR which is also consistent with our study.¹³ The study of R. Altin, S. Ozkurt et al on prevalence of byssinosis showed a reduction in FVC and FEV1 which is also consistent with our study. They also showed a statistically significant correlation between respirable dust concentration in the work place and byssinosis.¹⁴

The study of Pulmonary function by Yih-Ming Su, Jenn Rong Su et al showed decreases in FVC, PEFR, FEV1/FVC%, FEF 25-75% which is also consistent with our study.¹⁵ The study of Mentenot Woldeyohannes, Yves Bergevin et al in Ethiopia showed a decrease in Pulmonary Function in workers exposed to cotton dust which is in agreement with our study.¹⁶

Our study is also consistent with the findings of D.Choudat, F. Neukirch et al who showed a significant decrease in FVC and FEF 25-75% in cotton exposed workers.¹⁷ The study of David C Christiani, Ellen A Eisen et al showed that byssinotic workers had a decreased base line FEV1 and FEV1 / FVC%. Increasing duration of exposure resulted in increasing acute decrements in FEV1 which is consistent with our present study (when pulmonary function of 20-30 years male cotton exposed group is compared to 40-50 year male cotton exposed group).¹⁸

The cross-sectional study of respiratory symptoms and lung function by David Fishwick, Angela M Fletcher in Lancashire spinning mills showed that there is a loss of Lung Function in association with Exposure to Cotton Dust, when FEV1 and FVC are considered which is also consistent with our study. They postulated that the cotton

dust acts on larger airways to cause decrease in Pulmonary Function.¹⁶ Our present study is also consistent with the study of Yuna Zhong, Dehong Li et al who showed an overshift drop in FEV1.¹⁹

K.Y. Mustafa, A.S. Lakha et al studied spirometric lung function tests and found that high prevalence of byssinosis is associated with chronic and acute changes in FVC and FEV1 which is in agreement with our study. The extent of the fall in FEV1 correlated with the severity of byssinosis.²⁰

The study of Siziya S, Munalula B et al in cotton spinning mill in Zambia estimated the level of Lung Function impairment among cotton spinning mill workers to be 7.7% which is in agreement with our study.²¹ The cross-sectional study undertaken in Addis Ababa in 2006-2007 showed that the highest prevalence of respiratory symptoms were found in the carding section with a prevalence of about 84.6%.

A.J Mehta, X-R Wang studied the work area measurements of Endotoxin and observed a linear association between Vertical Elutriator measures of endotoxin and IOM (Institute of Occupation Medicine) personal inhalable dust sampler endotoxin concentration.²² Significant FEV1 decrements occurred after exposure to cotton dust, independent of atopic status in a study done by M J Sepulveda, R M Castellan et al, which is also in agreement with our study.²³ In a study of occupational lung disease in women by Y Wai and S.M Tarlo from Toronto Western Hospital exposure to organic dust with resulting Endotoxin exposure has been associated with chronic Bronchitis and Byssinosis.²⁴

Anita. J, Jadhav, Shithal R. Manhar, Chandrasekar D. Dange studied effect of exposure of cotton dust on PFT in female workers of spinning mill at Malegaon, Maharashtra and found greater declines in forced vital capacity, forced expiratory volume in first second. This reduction was significant in FEV1/FVC which is indicator of early obstructive pattern in the exposed group. As duration of exposure increases FVC reduces and showed restrictive pattern, which is also in agreement with our study.^{25,26}

Omid Aminian, Seyed Amir etc studied pulmonary function tests in cotton textile workers and found greater declines in forced vital capacity (FVC), forced expiratory volume in first second (FEV1) and FEV1/FVC in cotton textile workers. This reduction was significant in FEV1/FVC which is indicator of obstructive pattern in the exposed group. (P-Value: 0.04).²⁶

Table 1: Comparison of pulmonary function test parameters in males exposed to cotton and non-exposed (30-40 years Group 2)

	Non exposed 30-40years		Exposed 30-40 years		T value	P value	Crude value	%↑↓
	Mean liters/min	S.D	Mean liters/min	S.D				
FEV1	3.21	0.25	2.44	0.04	14.8	0.001	0.77	23.98↓
FVC	3.41	0.31	2.90	0.03	8.08	0.001	0.51	14.95↓
FEV1/FVC%	94.57	5.69	83.9	1.65	10.02	0.001	10.67	11.28↓
PEFR	6.30	0.84	1.55	0.37	22.2	0.0001	4.75	75.3↓
FEF 25-75%	3.50	0.32	1.33	0.19	30.47	0.0001	2.17	62↓

FEV1= forced expiratory volume in 1st second, FVC= forced vit al capacity, PEFR= peak expiratory flow rate, FEF= forced expiratory flow, S.D= standard deviation.

Table 2: Comparison of pulmonary function test parameters in males exposed to cotton and non-exposed (40-50 years Group 3)

	Non exposed 40-50years		Exposed 40-50 years		T value	P value	Crude value	%↑↓
	Mean liters/min	S.D	Mean liters/min	S.D				
FEV1	3.12	0.07	2.32	0.06	42.22	0.0001	0.8	25.64↓
FVC	3.35	0.17	2.82	0.09	11.2	0.0001	0.53	15.82↓
FEV1/FVC%	93.34	5.10	82.4	3.27	8.91	0.0001	10.94	11.72↓
PEFR	5.30	0.60	1.37	0.23	25.32	0.001	3.93	74.15↓
FEF 25-75%	3.33	0.20	1.25	0.06	57.63	0.001	2.08	62.46↓

Table 3: Comparison of pulmonary function test parameters in females exposed to cotton and non-exposed (30-40 years Group 2)

	Non exposed group 30-40 years		Exposed group 30-40 years		T value	P value	Crude value	% ↑ ↓
	Mean liters/min	S.D	Mean liters/min	S.D				
FEV1	2.7	0.16	2.29	0.01	12.2	0.0001	0.41	15.18↓
FVC	3.2	0.152	3.11	0.12	2.67	0.013	0.09	2.80↓
FEV1/FVC%	84.68	7.14	73.99	3.24	7.67	0.0001	10.78	12.73↓
PEFR	4.18	0.19	3.91	0.15	4.63	0.0001	0.27	6.45↓
FEF 25-75%	3.34	0.17	2.94	0.09	8.96	0.0001	0.40	11.90↓

Table 4: Comparison of pulmonary function test parameters in females exposed to cotton and non-exposed (40-50 years Group 3)

	Non exposed group 40-50 years		Exposed group 40-50 years		T value	P value	Crude value	%↑↓
	Mean liters/min	S.D	Mean liters/min	S.D				
FEV1	2.57	0.12	2.2	0.15	10.6	0.001	0.37	14.3↓
FVC	3.11	0.14	2.99	0.11	3.20	0.004	0.12	3.85↓
FEV1/FVC%	83.0	5.09	73.9	6.69	5.40	0.001	9.10	10.96↓
PEFR	3.9	0.09	3.71	0.19	4.40	0.001	0.19	4.8↓
FEF25-75%	3.10	0.16	2.68	0.12	12.8	0.001	0.42	13.5↓

Conclusion

Byssinosis is a world-wide occupational health hazard. The prevalence of byssinosis is decreasing in industrialized countries while it remains at high levels in developing countries. Cotton processing is known to produce a respiratory disease, particularly in the early processes of

cotton spinning. Chest tightness and breathing difficulty on Monday is found higher in the reeling, carding and drawing sections. In our study, there was a significant decrease in pulmonary function in human beings exposed to cotton fiber compared to controls. The FVC, FEV1, PEFR and FEF25-75% are effort dependent and were uniformly decreased in cotton workers. The prevalence of byssinosis increased with increase in years of exposure due to cumulated effect of

endotoxin. The byssinosis occurs more in cotton mill house particularly in those who are exposed to high concentrations of dust for a long period.

Preventive measures are of supreme importance in minimizing the prevalence of byssinosis and other respiratory disorders. Controlling dust, using face masks and closed cotton processing can reduce the risk to a significant extent. It is recommended for the employer to provide medical surveillance of those employees exposed to cotton dust. They are generally checked for FVC and FEV1. For new employees this examination shall be provided prior to initial assignment. With these prophylactic methods we can prevent or detect the problem early.

Conflict of Interest: None.

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