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Original Research Article

COMPARATIVE ASSESSMENT OF SPIROMETRY PARAMETERS IN NON SMOKING FLOUR MILL WORKERS VERSUS GENERAL POPULATION FOR EARLY DETECTION OF LUNG FUNCTION ABNORMALITIES IN NON SMOKING FLOUR MILL WORKERS

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ABSTRACT

Background: Indoor air pollution is a major problem in developing countries and is increasing more and more due to rapid industrialization and ineffective pollution control measures.1 Wheat flour dust is a complex organic dust with varied composition and consists of particles ranging from as small as 1 µm to greater than 20 µm in size. It causes symptoms throughout the respiratory tract, ranging from rhinitis to chronic bronchitis and asthma in the lungs. Spirometry plays a significant role in the assessment of extent of lung dysfunction and describes the effects of obstruction or restriction on the lung function. The aim and objective is to study the relation between pulmonary function test's abnormalities due to exposure to flour dust. To assess the utility of spirometry as a tool, for early detection of lung function abnormalities in workers exposed to wheat flour dust.

Materials and Methods: Non smoking, healthy 100 adult flour mill workers and age, body mass index matched 100 adult subjects from general population who are not exposed to flour dust were included in the study. The enrolled subjects performed spirometry after following all the necessary pre-requisites in both cases and controls and the results were analyzed by using student's t-test.

Results: Flour dust exposure causes respiratory symptoms and is associated with impairment of lung function. In this study, flour mill workers showed a significantly greater percentage decline in FVC, FEV1, FEF25-75%, PEFR, and also a significant decrease in FEV1/FVC ratio which is a suggestive of obstructive pulmonary disorder. There was statistically significant decrease in the level of ratio of FEV1/FVC in flour mill workers compared to controls (<0.001). It was observed that the level of FEV1/FVC decreased with increase in duration of exposure. The decrease in FEV1/FVC with duration of exposure was statistically significant.

Conclusion: The findings of present study suggests the derangement in pulmonary function in flour mill workers are as a consequence of exposure to flour dust which causes obstructive ventilatory defect. It is suggested that all flour mills must have well ventilated workplace and workers should be educated regarding potential health hazards at workplace with workplace appropriate personal protective equipments to be provided during duty hours.
Keywords: Flour mill workers, Pulmonary function test, Wheat flour dust, Personal Protective equipments.

INTRODUCTION

Hazardous exposures in the workplace and elsewhere in the environment continue to contribute to the burden of lung disease. With increasing concerns regarding the health effects of environmental and occupational exposures, such as exposures following the World Trade Centre collapse, clinicians must be prepared to recognize, diagnose, and manage occupational and environmental lung diseases. As patient access to sources of information regarding such exposures expands, health care providers must also be prepared to provide preventive advice and to address patient's concerns regarding such exposures.[1-3]

The workers of agricultural industry are highly exposed to harmful factors in their working environment, such as dust, excessive noise, unfavorable microclimatic condition and insufficient light.[4,5]

Dust is tiny particles dispersed in air due to mechanical disintegration of grains, rocks, minerals and other materials by impulsive forces such as drilling, blasting, crushing, grinding, milling, sawing and polishing or due to the agitation or breaking down of organic materials such as cotton fibers, pollens and fungal spores.[5] The occupationally related respiratory diseases are most likely to be due to deposition of dust in lungs and are influenced by the sort of dusts, the periods of exposure, the concentration and size of airborne dust in breathing zone.[6]

Wheat flour dust is a complex organic dust with varied composition, including particles of husk, cuticular hair, pollen, starch grains, bacteria and mucous spore.4, 7Wheat is one of the most common grains used to make flour. The flour varies in weight, compressibility and moisture content. The typical composition of wheat flour is 14 % protein, 2 % oil, 1 % cellulose and 81 % non-nitrogenous materials. Wheat is composed of a germ, starch and gluten cells which are enclosed by fibrous coats. Seed are composed of 85 % endosperm, 2 % embryo or germ and 13 % husk (bran). They are ground to produce flour. Milling removes the non-digestible bran coats, the germ and reduces the remaining starch and gluten to a fine powder. Wheat flour contains small amounts of naturally occurring alpha amylase, ranging from 0.1 to 1 mg/g flour.

Wheat flour dust consists of particles ranging from as small as 1 µm to greater than 20 µm in size. When whole wheat flour is further refined to separate the husk and the bran to leave behind very fine flour, the resulting flour is called all-purpose flour or Maida. Maida is white in colour that is the endosperm part of the wheat grain. Maida is a finely milled flour and is usually refined using a fine mesh of 600 mesh per inch (236 mesh per centimeter).Maida is processed wheat flour which is white in color, bleached with azodicarbonamide, chlorine gas, benzyl peroxide or other bleaches. It is a respiratory sensitizer and chronic exposure to it could affect the pulmonary functions and stimulate allergic responce.[8]

It causes symptoms throughout the respiratory tract, ranging from rhinitis to chronic bronchitis and asthma in the lungs. Several clinical syndromes have been attributed to grain dust exposure, which may reflect the complex composition of grain dust.[9]

The respiratory tract has a limited number of ways to respond to injury. Acute responses include rhino sinusitis, laryngitis, upper airway obstruction, bronchitis, alveolitis and pulmonary edema. Chronic responses include asthma, bronchitis, parenchymal fibrosis, pleural effusion and cancer. Early recognition and appropriate treatment of occupational lung diseases can significantly reduce both morbidity and mortality and greatly impact patient outcome.[10]

Spirometry plays a significant role in the assessment of extent of lung dysfunction and describes the effects of obstruction or restriction on the lung function.[11]

The twentieth century has seen an increasing recognition of the many lung diseases that can be caused by exposure to harmful substances in the workplace.[12] Annually an estimated 160 million new cases of work related diseases occur worldwide and respiratory diseases are one of the most common.[13]

Most respiratory diseases, including asthma, chronic obstructive pulmonary disease (COPD), interstitial lung disease, and lung cancer may be caused or exacerbated by factors in the workplace, but rarely are such disorders distinguishable pathologically or clinically from idiopathic or non-occupational causes. Thus, a high level of suspicion and knowledge of the basic approaches used in the diagnosis and management of occupational and environmental disorders is essential for all practitioners.

Several flour mills are located in our cities and a large labour workers are employed in these flour mills, which are mainly produces wheat flour

(maida). Hence this study was undertaken to evaluate the effect of wheat flour dust (maida) on respiratory functions of flour mill workers in view of a growing body of literature, that has expanded our understanding of several aspects of occupational and environmental lung diseases, including a substantial contribution of workplace exposures to the development of COPD and asthma, adverse health effects related to flour mill workers at their work place.

Aims & Objectives

- To study the lung function parameters Pre and post bronchodilation by spirometry to assess obstruction in non-smoking flour mill workers and compare the same with controls.
- To study the relation between lung function abnormalities and period of exposure.
- To assess the utility of spirometry as a tool, for early detection of lung function abnormalities in workers exposed to wheat flour dust (maida).

MATERIALS AND METHODS

Study area: This study was conducted in Department of Respiratory Medicine at a tertiary care hospital in India. This hospital works as a referral centre for diagnostic and therapeutic work up for chest diseases.

Study Design: Cross-sectional, Case-control study

Study period: Study was conducted for period of 1 year from November 2014 to November 2015, which included 9 months for data collection and 3 months for data entry and data analysis.

Sampling type: Purposive sampling

Inclusion criteria:

- All worker of wheat flour mill.
- Age: 18 to 50 years
- Nonsmoking, healthy male workers.
- Worker who have signed informed and written consent form and wish to voluntarily participate in the study.
- Normal healthy subjects between age group of 18 to 50 years will include as controls.

Exclusion criteria:

- Workers, whose age is less than 18 years or more than 50 years.
- Smokers
- Females
- Workers with previous history of respiratory diseases like COPD, Asthma, etc.
- Workers with signs and symptoms of respiratory infection at the time of test.
- Workers with abnormalities of vertebral column or thoracic cage.
- Workers with known history of neuromuscular disease, malignancy and those who have undergone major thoracic or upper abdominal surgery.
- Persons with known history of hypertension, diabetes mellitus. Ischemic cardiac diseases.
- Workers who have not signed informed and written consent form and do not wish to voluntarily participate in the study.

Study Population: The target population for study was non-smoking wheat flour mill (maida) workers as cases and their controls matched for age and Body Mass Index from general population.

Sample size & sample technique:

1. Based on inclusion criteria 100 wheat flour mill workers were identified. All wheat flour mill workers and were assessed eligibility at chest hospital and 100 workers were enrolled as cases in the study after taking Informed and written consent.
2. A health checkup camp was organized at chest hospital for general population and age, BMI matched 100 subjects were taken as a control group from general population.

Data collection technique and tools: A pre tested structured study proforma was used to collect the relevant information. Brief personal information like age, sex was entered in the patient information chart giving a separate Identification Number for each subject. A clinical examination of all the systems was done to exclude medical problems and to prevent confounding of results.

Pulmonary function test (spirometry) was carried out and forced expiratory spirograms have been obtained by pneumotrac (spirotrac 6800) in the morning before going to their work at chest hospital Calicut, Kerala. The Spirometry (pre and post bronchodilator) parameters forced vital capacity (FVC), forced expiratory volume in 1st second (FEV1), the ratio of FEV1/FVC, forced expiratory flow in the middle half of FVC (FEF25-75%), peak expiratory flow (PEF) were recorded.

FEV_1 and FVC manoeuvre14-17, 18

Definitions: FVC is the maximal volume of air exhaled with maximally forced effort from a maximal inspiration, i.e. vital capacity performed with a maximally forced expiratory effort, expressed in liters at body temperature and ambient pressure saturated with water vapor (BTPS).FEV1 is the maximal volume of air exhaled in the first second of a forced expiration from a position of full inspiration, expressed in liters at BTPS.

Test procedure: There are three distinct phases to the FVC manoeuvre, as follows:

- Maximal inspiration
- A ‘‘blast’’ of exhalation
- Continued complete exhalation to the end of test (EOT).

Summary Of Within- And Between-Manoeuvre Acceptability Criteria

A. Within-manoeuvre criteria:

Individual spirograms are ‘‘acceptable’’ if

1. They are free from artifacts

- Cough during the first second of exhalation
- Glottis closure that influences the measurement
- Early termination or cut-off
- Effort that is not maximal throughout
- Leak

- Obstructed mouthpiece

2. They have good starts

- Extrapolated volume, 5% of FVC or 0.15 L, whichever is greater

1. They show satisfactory exhalation

- Duration of 6 s (3 s for children) or a plateau in the volume–time curve or If the subject cannot or should not continue to exhale

B. Between-manoeuvre criteria:

After three acceptable spirograms have been obtained, apply the following tests.

- The two largest values of FVC must be within 0.150 L of each other
- The two largest values of FEV1 must be within 0.150 L of each other

If both of these criteria are met, the test session may be concluded

If both of these criteria are not met, continue testing until

- Both of the criteria are met with analysis of additional acceptable spirograms

or

- Total of eight tests have been performed (optional)

or

- The patient/subject cannot or should not continue
- Save, as a minimum, the three satisfactory maneuvers

Subject was motivated prior to the initiation of manoeuvre. Then each subject were prepared and coached to perform Spirometry properly as per the "ATS/ERS Task Force: STANDARADISATION OF LUNG FUNCTION TESTING".18 He was made to sit on a stool, then place the mouth piece firmly in his mouth. He was asked to take a maximum inspiration following which we would attach a nose clip and ask him to execute a maximum forced expiration with full efforts which was followed by a maximum forced inspiration.

The Spirometry manoeuvre was performed using the ATS/ERS Task Force guidelines for standardization of Spirometry.18 All the tests were done by pneumotrac (spirotrac 6800). It is a flow-sensor based digital spirometer. All the Spirometry tests were done in sitting position and subjects used nasal clips. The subjects were also instructed about the standard forced Spirometry maneuvers, each of them performed at least 3 reproducible attempts.

The following Spirometry parameters were recorded:

1. FVC
2. FEV_1
3. FEV_1/FVC
4. $FEF_{25-75\%}$
5. PEF

All lung function parameters should be reported at body temperature and pressure saturated with water vapour (BTPS). If this is not done the results will be underestimated because when the patient blows into a "cold" spirometer, the volume recorded by the spirometer is less than that displaced by the lungs.

Reversibility of Airflow Obstruction (post bronchodilator)

To measure the degree of reversibility (typically increased in asthma) of airflow obstruction, we performed Spirometry before and 10-15 minutes after administering a bronchodilator by pMDI with a valve holding chamber (Aero Chamber). Significant reversibility is implied if there is an improvement of > 12 % of baseline FEV1 and 200ml.

Accurate and reproducible measurements can be influenced by the amount of bronchodilator delivered to the airways. Studies have demonstrated that a reduced amount of bronchodilator to the airways can result in less than maximal bronchodilator improvement. As a result, patients tested would not demonstrate the optimal results, which the bronchodilator could deliver.

The test was performed over three maneuvers. The test with the best manoeuvre was selected. The machine gives the comparison of various parameters between the three maneuvers and we accepted the best manoeuvre. The results for each parameter were compared between subject and the control and were statistically analyzed.

Classifying Abnormal Ventilatory Function

Obstructive lung disease	Restrictive lung disease
High TLC	Decreased TLC
LOW $FEF_{25-75\%}$	Normal FEF25-75%
VC normal / increased	Decreased VC
FEV_1 decreased	FEV1 normal
FEV_1/FVC decreased	FEV1/FVC normal

Data analysis: The results were given as Mean ± Standard Deviation and range values. Comparisons were performed using student's t-test for two group comparisons (wheat flour mill workers and their match from general population) and one way ANOVA (Analysis of Variance) for multiple groups. Chi square test was used to test association between qualitative variables.

The p value of 0.05 or less was considered as statistically significant. Analysis of data was carried out with using SPSS (Statistical Package for the Social Sciences) software.

RESULTS

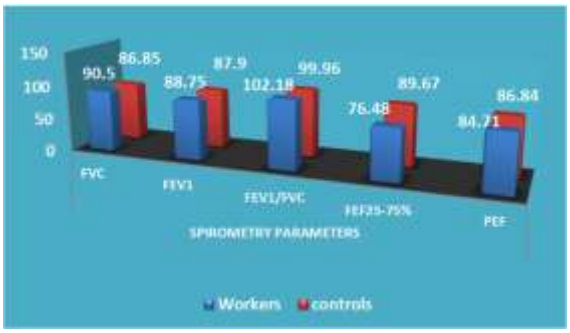
1. In this study, wheat flour mill workers showed a significantly greater percentage decline in $FEF_{25-75\%}$ (76.48±21.63 % of predicted in wheat flour mill workers as compare to control who had 89±9.4 % of predicted). It was statistically significant. The post bronchodilator Mean ± SD of $FEF_{25-75\%}$ (L/sec) in Wheat flourmill workers was 77.37 ± 18.76 % as compared to controls which had 90.24 ± 10.19 % and it was too statistically significant ($p<0.001$).

There was statistically no significant change in the level of FVC, FEV_1,

FEV_1/ FVC and PEF in the wheat flourmill workers compared to controls.

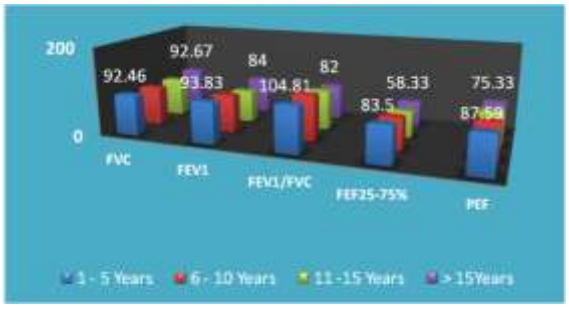
Comparison of Spirometry Parameters (FVC, FEV_1, FEV_1/FVC, $FEF_{25-75\%}$, PEF) Between Wheat Flour Millworkers and Controls.

Spiromery Parameters	Workers (N= 100)	Controls (N=100)	t-value	p-level
FVC	90.50±18.07	86.85±16.64	1.486	0.139
FEV_1	88.75±17.57	87.90±13.08	0.388	0.698
FEV_1/ FVC	102.18±11.24	99.96±10.64	1.434	0.153
$FEF_{25-75\%}$	76.48±21.63	89.67±9.4	- 5.683	0.000
PEF	84.71±16.94	86.84±13.93	- 0.939	0.334



2. Workers who were exposed to wheat flour dust for 1-5 years had FEV1 93.83±14.23, FEV1/FVC ratio 104.81±8.08, and FEF25-75% 83.5±20.09, and it was observed significant decrease in FEV1, FEV1/FVC ratio, FEF25-75% with increasing duration of exposure to flour dust. In workers who exposed to wheat flour dust more than 10 years had declined FEV1, FEV1/FVC ratio and FEF25-75% 84.00+17.57, 82.00+19.40 and 58.33+11.06 respectively.

Duration of exposure (in years)	N	FVC (% pred)	FEV_1 (% Pred)	FEV_1/FVC (% Pred)	$FEF_{25-75\%}$ (% Pred)	PEF (% Pred)
1– 5	54	92.46±16.31	93.83±14.23	104.81±8.08	83.5±20.09	87.59±14.21
6-10	32	88.41±21.56	85.91±20.00	103.78±10.25	72.22±22.06	83.04±20.86
11-15	11	86.36±17.40	73.36±15.76	90.09±13.21	59.39±14.66	78.00±16.63
>15	3	92.67±11.01	84.00±17.57	82.00±19.40	58.33±11.06	75.33±8.30
	F	1.002	4.923	8.424	16.469	1.602
ANOVA	P	0.408	0.001	0.000	0.000	0.172



Comparision of spirometry parameters in relation with duration of exposure to wheat flour dust in wheat flour mill workers.

Thus spirometry parameters showed statistically significant decrease in FEV_1, FEV_1/FVC, $FEF_{25-75\%}$ on long term exposure (> 10 years) to wheat flour dust. FVC and PEF values showed a decreasing trend with increasing duration of exposure but the decrease was not significant statistically.

Though FEV_1/FVC < 70 which is marker of obstruction was found only 1% in worker's group, the $FEF_{25-75\%}$, which is sensitive for small airway obstruction was significantly declined. Thus, Spirometry as a screening tool, for early detection of lung function abnormalities in workers exposed to wheat flour dust is very useful noninvasive technique.

DISCUSSION

Occupational respiratory diseases are usually caused by extended exposure to irritating or toxic substances that cause acute or chronic respiratory ailments.[19] The incidence depends upon the chemical composition of the dust, size of the particles, duration of exposure and the individual susceptibility. Though the developed countries are very careful about occupational health, it is quite neglected in developing countries like India. Wheat Flour mills produce a large amount of dust. On an average, Wheat flour mill workers are exposed to the workspace environment for 8 – 10 hours a day and there are no provisions for minimization of the dust produced in the wheat flour mills in our country. Poor ventilation is a basic problem in wheat flour mills which leads to accumulation of the dust. Cumulative exposure to dust results in chronic pulmonary diseases. Spirometry is one of the easy tools to direct lung function abnormalities at an early stage so that preventive measures can be adapted before irreversible changes set in.[20]

This study showed that there is decrease in FEV1, FEV1/FVC and FEF25-75%with increase in the duration of exposure to flour dust. These findings correlate with those of Meo SA and Al-Drees AM4, Yadav BN et al and Meo SA.[21,22] Moreover, Though FEV1/FVC < 70 which is marker of obstruction was found only 1% in worker's group, the FEF25-75%, which is sensitive for small airway obstruction was significantly declined.

FVC declines more with an increase in duration of exposure were reported by Wagh ND et al,[1] Meo SA and A1-Drees AM4, Meo SA,[22] Awad et al,[23] and Ahmed AH et al.[24] Fall in FVC among the Wheat flour mill workers may be due to the

accumulation of flour dust particles in the lung airways.[1] The cumulative exposure to dust impairs the phagocytic efficiency of alveolar macrophages and also affects the muco-ciliary performance. The irritation by dust probably leads to hypertrophy of mucosal cells resulting in increased secretion of mucus and formation of mucosal plugs which causes obstruction for the exhalation of air.[25] When the dust particles are inhaled, scavenger cells like macrophages dissolve the dust by surrounding it, but if there is too much of dust and overload situation, the scavenger cells cannot completely clear the dust. Hence, the dust particles lodge in and irritate the lungs setting up an inflammation in the small airways and alveoli of the lung. As the inflammation heals, it leaves a scar tissue called fibrosis. This causes thickening of the lining of the airways and leads to obstruction.[20]

Fall in FEV1 among the Wheat flour mill workers may be attributed to accumulation of flour dust particles in the lung airways and the resultant mucosal hypertrophy.1, 25 Flour dust is a respiratory sensitizer and chronic exposure to it stimulates the allergic responses.

FEV1 /FVC ratio is a more sensitive index than FEV1 or FVC alone. It is used as Diagnostic criteria of obstructive airway disease. exposure to flour dust leads to change in FVC and FEV1 and therefore affects FEV1 / FVC ratio.

The initial part of the expiratory FVC curve, FEF25-75% depends upon non broncho-pulmonary factors like neuromuscular and mechanical factors of inertial distortion of lungs. FEF25-75% is a sensitive test for the presence of obstructive small airway disease. FEF25-75% indicates patency of small airways26. Decline in FEF25-75% can be attributed to the obstruction caused by the accumulation of dust particles.[25,26]

The lower values of PEF among flour mill workers could be due to hypertrophy of mucosal cells due to irritation by grain dust.[25] The respiratory effects of flour dust are also believed to result from wheat flour proteins including albumins and globulins, flour parasites and added enzymes.

Thus, Spirometry as a screening tool, for early detection of lung function abnormalities in workers exposed to wheat flour dust is very useful noninvasive technique.

CONCLUSION

The present study correlates with earlier findings that the derangement in pulmonary function in Wheat flour mill workers is a consequence of chronic irritation by wheat flour dust which causes obstruction for the exhaled air especially in small airways and increases risk to the development of obstructive airway disease in later life. It is suggested that all flour mills must be well ventilated and workers should be provided with masks during duty hours and the occupational hazard needs further evaluation. The unorganized sector of wheat flour mill seems to be at significant occupational risk and they need to be made aware of the risk and offered the coverage for risk by suitable legislation.

Recommendations:

1. All flour mills must be well ventilated.
2. All workers should be provided with masks during duty hours.
3. All wheat flour mill workers should undergo regular health checkup and screen with spirometry for early detection of lung function abnormality.
4. The sector of wheat flour mill should be made aware of wheat flour dust's hazardous exposure.
5. The occupational hazard of wheat flour dust needs further evaluation.

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