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Original Article

Relationship between Lung Function and Flour Dust in Flour Factory Workers

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Abstract

Introduction: Exposure to flour dust is an important risk factor in occurrence of allergic airway disorders among mill workers. The purpose of this study was to determine the prevalence of †respiratory symptoms and its relation with exposure to respirable dust.

Materials and Methods: In this study, all of 35 workers who worked in the flour producing section of three factories were chosen as case group and 20 unexposed people were selected as the control group. Exposure to total and respirable dust were measured with standard methods. Spirometry was used for determining lung function disorders and the America Lung Society Questionnaire was used for assessment of prevalence of respiratory symptoms. The results were analyzed by t-test, correlation and linear regression.

Results: The average total and respirable dust exposure in the exposed group was 8.06 and 5.09 mg/m^3 and was higher than the threshold limit value recommended by American Conference of Governmental Industrial Hygienists(ACGIH). 52% of workers had sputum in the morning and during waking up, 44% felt tightness of breath or pressure in the chest, 55% felt short of breath while walking fast and work; and in 52% cough during work was experienced. There was a significant and negative correlation between total and respirable dust with Forced Vital Capacity(FVC), Forced Vital Capacity Percent(%FVC) and Forced Expiratory Volume in one second(FEV_1).

Conclusion: The results of this study indicate that exposure to respirable dust was more than 10 times higher than the threshold limit and caused a high prevalence of respiratory symptoms and lung function disorders among mills workers.

Keywords: Flour; Lung ; Occupational Exposure; Signs and Symptoms, Respiratory

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Introduction

Exposure to flour dust and related enzymes is one of the most common causes of allergic rhinitis, chronic respiratory disorders including asthma and occupational airway diseases [1-6]. In many industries such as flour mills and bakeries, the dust generated during cleaning, grinding, packaging and transport is released in the atmosphere and can be inhaled [7, 8]. Bernardino Ramazzini reported illnesses associated with milling and baking as early as 1700 which included symptoms such as cough, shortness of breath, hoarseness, asthma, and eye problems [9-11].

Mill and bakery workers' clinical manifestations include conjunctivitis, allergic and baker's asthma, wheezing, febrile reactions, grain fever, lung fibrosis, rhinitis, allergic alveolitis, impairment of lung function, and chronic obstructive pulmonary disease [8].These respiratory symptoms with continuing occupational exposure can lead to worker disability [12].

The albumin portion of flour is the main cause of allergies that known as "Baker's asthma" (BA) and inhaling it leads to the stimulation of the specific antibodies, increased allergies, respiratory disorders and ultimately asthma [13]. Baker's asthma and rhinitis are some of the most frequent occupational respiratory disorders in western countries. Bakers asthma prevalence in Asian countries has significantly increased in the recent years [11, 12,14].

Asthma caused by flour dust is described with a latent period between first exposure and development of symptoms, which varies from a few weeks to 35 years. However, on average, intense symptoms of allergic rhinitis occur after 8 to 9 years and asthma after 13 to 16 years of exposure [7].

Lung diseases are classified as obstructive, restrictive or combination forms. In occupational respiratory diseases, spirometry is one of the important diagnostic tools. Spirometry plays a significant role in the diagnosis and prognosis of these diseases and shows the effect of restriction or obstruction on lung function [5, 8]. In the literature a few studies have investigated pulmonary function in bakers [15]. Recently several studies reported high exposure levels to total and respirable dust in mill workers [5, 7] and have documented that exposure to flour dust increases the risk of respiratory diseases, particularly occupational asthma [9, 13, 14, 16].

Several studies have been reported high rates of sensitivity to flour allergens and the alpha-amylase enzyme and also the prevalence of airways disease and occupational asthma among workers exposed to flour dust [5, 17-19]. A study from Canada showed that about 97.1% of mill workers were exposed to more than 0.5 milligrams per cubic meter of dust [7] and a study done in Iran showed that lung function was significantly reduced due to exposure to flour dust above the safe limits [5].

The aims of the present study were quantitative assessment of total and respirable dust exposure using standard methods and determine relationship between dust exposure and lung indices. In addition to the prevalence of respiratory symptoms, America Lung Society Questionnaire was used.

Materials and Methods

This was a cross-sectional study conducted in three flour producing factories in Kerman, Iran in 2013. Out of 42 production staff, 35 workers in the winnowing, grinding, loading-storage and bran warehousing sections were enrolled. All employees worked 42 hours per week in one shift. Also they haven't any personal protective equipment or their used equipment that were inappropriate. Due to lack of more people with similar condition to exposed peoples, only twenty cases were access to as control group. Controls were selected from people who had been working in similar conditions (time of work, workplace, environment condition, view of management, Fringe benefit) but were not exposed to flour dust. Employees who had a history of asthma or lung disease prior to employment in this occupation and smoking workers were excluded (8 numbers). This study was carried out in two stages. First the amount of workers' exposure to flour dust was determined, second the workers respiratory symptoms and lung volumes were determined.

In the first step for flour dust sampling the NIOSH 0500 and NIOSH 0600 standards were used for the measurement of total dust and respirable dust[20].According to this method, the 37 mm PVC 5-µm pore size filter accompanied with a cassette and flow rate of 2 liters per minute for total dust and the 25 mm PVC 5-µm pore size filter with a 10 mm plastic cyclone accompanied with a cassette were used for respirable dust. In order to weigh the filters precisely, the filters were placed before and after sampling in a desiccator for 24 hours and then were weighed by a scale at four decimal places. In order to remove the effects of environmental conditions on the sampling filters for both total and respirable dust filters, a control filter was also used.

The sampling sets were placed in the workers' breathing zone. According to the standard method, the sampling volume for total dust was selected between 7 and 133 liters and for respirable dust between 20 and 400 liters according to the amount of dust in the workplace's air. Then by using equation 1, the concentration of total and respirable dust collected per unit volume of air sampled was calculated.

$$C = \frac{(W_2 - W_1) - (B_2 - B_1)}{V}, mg/m^3$$

(Equation 1)

In this formula W_1 is the weight of filter before sampling (mg), W_2 is the post-sampling weight of the sample-containing filter (mg), B_1 is the mean weight of the control filters (mg) and B_2 is the mean post-sampling weight of the blank filters (mg).

Equally from each factory, twelve samples of total dust and twelve samples of respirable dust were taken. According to the grouping of jobs, 3 samples of total dust and 3 samples of respirable dust from each section (winnowing, grinding, loading-storage and bran warehousing) were taken.

In the second stage, to measure lung volumes a Vitalograph 2110 spirometer made in America was used. After calibration, the environmental and personal data were entered according to the manufacturer's manual, and then the lung volumes FVC (Forced Vital Capacity), FEV_1(Forced Expiratory Volume in one second), FEV_1/FVC and PEF(Peak Expiratory Flow) were measured. All spirometry in the sitting position and repeated 3 times for each person was performed.

In order to determine the respiratory symptoms, the questionnaire of the American Lung Association was used [21]. The questionnaire includes 2-part. The first part was related to general demographic items (age, height, weight and work history). The second part included different items about respiratory symptoms (35 questions).In order to compare the demographic characteristics, work history and lung volumes between the study and control groups t-test was used and to investigate the relationship between the amount of exposure to total and respirable dust and pulmonary volumes, and between pulmonary volume, age and work experience the Spearmen correlation coefficient was applied. Also to determine the relationship between pulmonary volumes and several independent variables linear regression was applied. $p<0.05$ was considered statistically significant. This study was approved by Kerman University of Medical Sciences Ethical Committee. All the participants signed informed consents before entering the study.

Results

The personal and occupational information of the exposed and control subjects such as age, weight, height and work history has been summarized in Table 1. There was no significant difference between the two groups in terms of demographic variables.

Table 1. Personal and occupational information of exposed and control subjects

	Exposed group Mean ±SD	Control group Mean ±SD	P-Value
Age	40.41±10.57	39.4±12.49	0.748
Weight	68.83±8.1	71.9±10.88	0.236
Height	172.16±5.96	174.95±7.46	0.132
Work history	12.08±9.68	10.45±5.59	0.493

The average of total and respirable dust exposure in the exposed group in different jobs types has been shown in Table 2. Loading-storage workers with 9.12±2.02 milligrams per cubic meter of total dust and 6.33±2.09 milligrams per cubic meter of respirable dust had the highest exposure.

Table 2. Workers' exposure to flour dust

Exposed group(number of people)	Total dust (mg/m^3)Mean ±SD	Respirable dust (mg/m^3) Mean ±SD
Winnow (9)	7.15±1.59	4.48±1.89
Mill (9)	7.63±2.51	4.45±2.40
Loading-storage (9)	9.12±2.02	6.33±2.09
Bran warehousing (8)	8.36±3.69	5.11±2.68
Total	8.06±2.58	5.09±2.31

In this study, 38 and 52% of workers had experienced cough and sputum respectively when waking up in morning. Also 44% of workers had chest tightness, 55% of them had exertional dyspnea while walking fast and working and 52% reported coughing while working. But none of these symptoms were reported in the control group. Respiratory volumes in both groups have been summarized in Table 3. All lung volumes were less in the exposed group and in some of them the difference was significant compared to the control group.

Table 3. Lung volumes in the exposed and control groups(liter)

Pulmonary volumes	Exposed group (Mean ± SD)	Control group (Mean ± SD)	P-Value
FVC	3.33±0.73	4.15±0.88	0.001
%FVC	73.02±12.07	84.40±14.12	0.001
FEV_1	3.04±0.64	3.41±0.91	0.056
$\%FEV_1$	78.47±13.44	83.35±14.87	0.098
$\%FEV_1/FVC$	91.21±12.7	81.83±10.43	0.006
PEF	378.6±114.2	580.95±359	0.003
%PEF	67.55±12.55	74.8±30.41	0.222

Spearmen correlation was used in order to investigate the relationship between total and respirable dust exposure and lung volumes in the exposed group (Table 4). There was a significant inverse correlation between dust exposure and FVC, %FVC and FEV1.

Table 4. Relationship between lung volumes and dust exposure

	Total dust		**Respirable dust**	
	P-Value	Coefficient	**P-Value**	Coefficient
FVC	0.00	-0.618	0.00	-0.593*
%FVC	0.017	-0.397*	0.014	-0.405*
FEV_1	0.00	-0.551*	0.004	-0.471*
$\%FEV_1$	0.079	-0.297	0.159	-0.24
$\%FEV_1/FVC$	0.381	0.151	0.125	0.261
PEF	0.853	-0.032	0.701	0.066
%PEF	0.619	-0.086	0.952	0.01

* The starred coefficients have been calculated by Spearmen's Correlation Coefficient

The effect of age and work history on pulmonary function variables were adjusted by linear regression in Table 5. Even after adjustment the inverse correlation between dust exposure and FVC, %FVC and FEV1 remained.

Table 5. The relationship between lung volumes and dust exposure adjusted for age and work history

	Total dust		Respirable dust	
	p-value	β coefficient	**p-value**	β coefficient
FVC	0.003	- 0.440	0.014	- 0.034
%FVC	0.05	- 0.301	0.043	- 0.311
FEV_1	0.03	- 0.325	0.056	- 0.288
$\%FEV_1$	0.218	- 0.2	0.186	- 0.215
$\%FEV_1/FVC$	0.43	0.14	0.41	0.146
PEF	0.304	- 0.154	0.877	0.023
%PEF	0.988	- 0.002	0.874	0.024

Discussion

In the bread industry, exposure to flour dust may cause diverse lung diseases with different severity of symptoms ranging from simple irritation to allergic rhinitis or occupational asthma [22]. Long term exposure to flour dust can cause chronic lung problems. Studying the respiratory effects of exposure to flour dust is essential for predicting factors that can cause asthmatic reactions [23].

The present study investigated occupational exposure to flour dust and its effects on lung function in flour factory workers in Kerman.According to the American Conference of Governmental Industrial Hygienists(ACGIH) standard, the threshold Limit Values of exposure to respirable flour dust is 0.5 milligrams per cubic meter which is also accepted by the Iranian Health Organization [24]. In this study, the average exposure to respirable flour dust in workers at various sections was 5.09±2.31

mg/m^3 and is ten times higher than the permissible limit. The maximum exposure to flour dust was seen in the loading-storage section due to direct contact with flour dust and the lowest exposure was in the winnow section probably because the process was confined.

According to Karpinski et al, in 110 workers of Canadian flour mills exposed to flour dust, 66 cases had exposure to over 5 mg/m^3; and 44 cases had exposure to over 10 $mg/m^3$of respirable dust flour [7]. The results of the present study showed that exposure to total dust was 8.06 (±2.58) mg/m^3. In Kakooei et al's study, average exposure to respirable and total flour dust was 4.99 and 12.11 mg/m^3respectively [5]. Despite the differences in sample size and location of study, the results of the two studies mentioned and this study indicates excessive exposure standard for workers exposed to flour dust.

In the present study, 38 percent of exposed subjects had experienced excessive coughing and 55% of them had exertional dyspnea while walking fast and working; but in Wagh et al study, these values were reported 34 and 42% respectively, while exposure to respirable dust was 0.624 milligrams per cubic meter [23].

In the present study, exposure to total and respirable flour dust is more than the values of Baatjies et al (2010, South Africa) and Elms et al (2005, England, Wales and Scotland) studies and less than the values of Mirmohamadi et al (2011, Iran, Mazandaran) and Neghab et al (2010, Iran, Fars) studies [4, 13, 16, 21]. The difference in results could be due to differences in environmental conditions, workload, ventilation systems and equipment used in the process are studied. The present study, showed a significant difference between the lung volumes such as FVC, %FVC, %FEV1/FVC ،PEF between the exposed and control groups.

According to the statistical tests and calculated Spearmen coefficient, there was a statistically significant relationship between the total and respirable dust exposure and lung volumes such as FVC, %FVC, FEV1 even after adjusting. The results also showed that with increasing age and work history, lung volumes reduced. Wagh et al, also observed significant reduction in some lung volumes such as FVC، FEV1 and PEFR in wheat mill workers compared to the normal values. They also found a reduction in lung volumes especially PEFR, FEV1 and FVC with increase in work history [23]. In Patouchas et al study, the relationship of work history and lung volumes reduction was investigated, but it was only significant for FVC [15]. The results of the above studies and the present study confirm that relationship between flour dust exposure and lung volume reduction is clearly shown.

Conclusion

The results from the present study indicate high exposure to flour dust in the flour factory workers of Kerman. These results indicate an urgent need for prevention programs, such as local and general ventilation and using appropriate respiratory masks that can play an important role in reducing exposure to flour dust. Also the use of new equipment and also enclosing the production process can reduce dust emissions in the air.

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