ORIGINAL ARTICLE

Respiratory and Pulmonary Function Problems among Flour Mills Workers in East of Iran

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Abstract

Background and Aim: Flour dust is one of the allergens dust in the workplaces, and its occupational exposure can cause respiratory impairments. The aim of this study was to investigate respiratory and pulmonary function problems in flour mills workers exposure to flour dust. **Materials and Methods:** This cross-sectional study was carried out at 11 flour-producing factories in Iran. Study subjects were including to 286 males (176 male workers with current exposure to flour dust and 110 male unexposed employees). Determination of dust concentration was carried out with personal dust sampler at all production wards of studied industries. Respiratory symptoms were investigated with American Thoracic Society questionnaire. Lung function tests were done by a calibrated spirometer. The statistical analysis was performed by SPSS 18 software and *t*-test, Chi-square, linear, and logistic regressions. **Results:** Age and job tenure means of exposed group were 35.2 ± 8.6 and 11.9 ± 6.03 years, respectively. This result, for unexposed group, too was gained 35.3 ± 8.5 and 10.89 ± 6.5 years, respectively. Atmospheric concentrations of respirable and inhalable dust were 12.4 ± 2.41 and 33.26 ± 3.47 mg/m^3, respectively. These results indicated that prevalence of respiratory symptoms in exposed subjects was significantly higher than non-exposed workers. Likewise, pulmonary function parameters were significantly lower in exposed than the reference group. **Conclusions:** The findings of this study showed that occupational exposure to flour dust could be a significant factor of the prevalence of respiratory symptoms and functional disorders of the pulmonary.

Key words: Flour mill workers, occupational exposure, pulmonary function, respiratory symptoms

INTRODUCTION

Flour dust is considered as one of the allergens in workplaces.[1] A large number of the workers in different occupations such as agriculture, flour industry, silo workers, bakery, and confectionery are exposed to flour dust, and the dust can result in respiratory asthma of the airways and other pulmonary damages.[2,3] Studies conducted on bakery and confectionery workers showed that dust in these occupations can lead to respiratory problems, reduction of pulmonary parameters, and respiratory allergy.[4-7] Findings of some studies demonstrated that being exposed to flour dust increases the allergy risk in people and induces allergy in the eye, nose, and airways of the pulmonary system.[1,8,9] In previous studies, it was observed that the amount of serum antigen in the group exposed to flour dust has a significant difference comparing to control group.[10] Breathing flour dust can induce allergy and chronic respiratory problems like asthma.[11,12] The outbreak

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of respiratory symptoms and chronic obstruction of the airways are observed in the workers exposed to heavy flour dust[13-16] and significant reduction of some pulmonary function parameters such as forced vital capacity (FVC), VC, forced expiratory volume in the first second (FEV_1), and peak expiratory flow rate (PEFR) is observed in the individuals exposed to dust.[17-21] The extent of dust effect on the respiratory system depends on the type and size of dust, density and the degree of airborne dust in the respiratory area of an individual.[22] Hence, the efficacy of different dust types is different in various environments.

Notwithstanding, the cause of great amount of wheat production (over 10 million tons in a year) and flour consumption in Iran,[18] many farmers, silo workers, workers of flour production industries, millers, bakeries and the like are exposed to this allergen. Regarding the small range of studies carried out on respiratory problems in the workers exposed to flour in Iran and also the limitations of the studies,[18] researchers decided to study a large sample size in six flour factories of Khorasan province to characterize workers exposure to the allergen and its effects on pulmonary function parameters and also determination levels of the pulmonary disorders prevalence. The main aim of the study was to investigate respiratory and pulmonary function problems in flour mills workers exposed to flour dust in Khorasan province, Iran.

MATERIALS AND METHODS

Subjects of the study

This cross-sectional study was conducted in six flour factories of Khorasan Razavi and Southern Khorasan provinces. The samples comprised 286 individuals (176 exposed and 110 non-exposed as reference group from official department employees of different industries who had no previous and present exposure to the flour dust). Individuals with a history of chronic pulmonary diseases (pre-existing medical conditions), asthma or pre-existing pulmonary infections like tuberculosis were excluded from the study. The present study was conducted based on Helsinki notice and its reform,[23] and all participants filled up and signed conscious agreement form.

Respiratory disorders symptom prevalence

Studying the respiratory symptoms was carried out using American Pulmonary Professionals Association' respiratory symptoms questionnaire.[24] Containing questions regarding to respiratory status of the individual (chronic cough, chest wheeze, short breath, mucus expulsion, and bronchitis,), eye and nose symptoms, taking tobacco, medical and family conditions of the individual, job, work background, and previous jobs (in particular jobs with a risk of respiratory diseases infection).

Measuring concentration of flour dust

To determine the extent of the worker's exposure to flour dust, respirable (<5 μ in diameter) and inhalable (≥5 μ) dust concentrations were examined in all the floors of the studied flour industries. To estimate the particles concentration in the given areas, calibrated personal sampling pump (made by SKC Co.) equipped with a 25 mm filter holder, a cyclone, and membrane filter (pore size 0.8 μ) was utilized at a flow rate of 2 L/min. Based on the pilot tests (pilot study), the optimized time to prevent excessive filter accumulation was determined to be 60 min. Respirable dust particle density determination was carried out through double weight filter technique and using Sartorius digital scale with sensitivity 0.1 mg. The content of cyclones was weighted to measure inhalable particles.[25]

Pulmonary function tests (PFTs)

According to American Thoracic Association instruction,[26-32] PFT include FVC, VC, FEV_1, and PEFR. They were measured on workplaces of the workers in different shifts and to a sufficient extent using portable calibrated spirometer (Mir factory, Italy). Mean expected percent was calculated for each functional parameter based on age, weight, height, sex, and race using spirometer device. The individuals were asked to take bath and avoid smoking at least 2 h before spirometry. Furthermore, for the individuals to get familiar with spirometry and respective maneuvers, required instructions were delivered. Their weights and heights were measured on-cloth. Before conducting the test, the individuals were settled at seating position for 5 min then, they were asked to stand as normal and relax in front of the spirometer, and put the specialized clip on their noses. Each individual was at least tested in triplet, and even for sextet; if there was a significant difference observed between FVC results. Then, the greatest volumes (in terms of expected pulmonary function percent) were selected for next analyses.[18,33-38]

Data analysis and statistical tests

Data analysis was carried out using SPSS18 Software. Mean distribution normality was examined using "single-sample Kolmogorov-Smirnov" test. To evaluate between quantitative variables means in two groups: Exposed and not exposed, *t*-test and the comparison frequencies between the two given groups, Chi-square test or exact Fischer test were conducted. Besides the exposure status, the relationship between pulmonary parameters was examined using independent variables including age, time of exposure, and smoking cigarette using multiple linear regressions. Role of variables includes age, time of exposure, and smoking cigarette in the chances of developing respiratory symptoms was evaluated using logistic regression model as well as the estate of individuals' exposure.

RESULTS

In this study, 176 exposed and 110 non-exposed individuals were examined. Individual characteristics of the participants are presented in Table 1. Mean age and work background or the exposure time (in exposure individuals) were, respectively, 35.2 ± 8.6 and 11.9 ± 6.03 years, and mean age and work background (in non-exposed individuals) were, respectively, 35.3± 8.5 and 10.89 ± 6.5 years. Results from t-student test showed that the two groups under study had no meaningful differences considering demographic variables.

Dust measurement and smoking status results are presented in Table 2. Flour dust density measurement in the sites under study demonstrated that mean respirable dust concentration, inhalable dust, and total dust are, respectively, 12.4 ± 2.4 mg/m^3, 33.26 ± 3.47 mg/m^3, and 45.66 ± 3.42 mg/m^3. Cigarette-addiction-wise distribution of the individuals also showed that the two groups have no meaningful differences ($P > 0.05$).

The estate of individuals respiratory symptoms is given in Table 3. As seen, the respiratory symptoms except sputum are statistically higher in the exposed group comparing to non-exposed individuals ($P < 0.05$).

PFTs results are presented in Table 4. Mean results of FVC, VC, FEV_1, and PEFR percent's, FEV_1 to PEFR ratio showed that the whole parameters were lower in the exposed individuals comparing to the non-exposed individuals and the difference was statistically meaningful ($P < 0.05$).

Table 1: Demographic characteristics of the study population according to the flour dust exposure

Study factor	Exposed (*n*=176)	Unexposed (*n*=110)	*P*†
Age (years)	35.2±8.6	35.5±8.5	0.920
Job experience (years)	11.98±6.03	11.89±6.50	0.157
Weight (kg)	72.6±1.2	74.7±1.16	0.165
Height (cm)	171.6±8.6	170.7±6.2	0.318

†Independent sample *t*-test

Table 2: Levels of flour dust exposure and smoking according to exposure status

Parameter	Exposed (*n*=176)	Unexposed (*n*=110)	*P*†
Respirable dust concentrations of flour	12.4±2.4	N/A	-
Inhalable dust concentrations of flour	33.26±3.47	N/A	-
The total concentration of flour dust	45.66±4.2	N/A	-
The distribution of consumption cigarette			
Yes	39 (22.2)	26 (23.6)	0.424
No	137 (77.8)	84 (76.4)	

†Chi-square test

Table 3: The frequency of respiratory symptoms in subjects with regard to exposure status

Symptoms	Exposed *n*=176 (%)	Unexposed *n*=110 (%)	OR	*P*†
Cough				
Yes	60 (34.1)	20 (18.2)	2.32 (1.30–4.14)	0.002
No	116 (65.9)	90 (81.88)		
Sputum				
Yes	52 (29.5)	28 (25.5)	1.22 (0.71-2.10)	0.27
No	124 (70.5)	82 (74.5)		
Wheezing				
Yes	61 (34.7)	18 (16.4)	2.71 (1.49–4.90)	0.000
No	115 (65.3)	92 (83.6)		
Dyspnea				
Yes	53 (30.11)	18 (16.4)	2.20 (1.21–4.01)	0.006
No	123 (69.9)	92 (83.6)		

†Chi-square test

Table 4: Results of measurements of lung function parameters in subjects with regard to exposure status

Pulmonary parameters	Exposed (*n*=176)	Unexposed (*n*=110)	*P*†
FVC	4.34±1.11	5.16±1.2	0.001
FEV_1	3.6±0.98	4.4±1.02	0.0001
FEV_1/FVC	83.7±8.8	86.3±11.1	0.003
PEF	6.5±1.7	7.6±2.1	0.000

†Independent sample *t*-test. FVC: Forced vital capacity, FEV1: Forced expiratory volume in the first second, PEF: Peak expiratory flow

Table 5: The effect on lung function parameters using multiple linear regression (*n*=176)

Pulmonary parameters	Independent variable	Coefficient of B	*P*†
FVC			
	Constant	4.585	0.000
	Age	−0.218	0.004
	Job experience	−0.090	0.235
	Cigarette	0.059	0.432
FEV_1			
	Constant	4.362	0.000
	Age	−0.302	0.000
	Job experience	−0.092	0.214
	Cigarette	0.006	0.933
FEV1/FVC			
	constant	94.425	0.000
	age	0.313	0.014
	Job experience	0.131	0.297
	cigarette	0.040	0.748
PEF			
	Constant	6.839	0.000
	Age	−0.019	0.798
	Job experience	0.138	0.077
	Cigarette	0.067	0.392

†Multiple linear regressions. FVC: Forced vital capacity, FEV_1: Forced expiratory volume in the first second, PEF: Peak expiratory flow

The relationship between function parameters and exposure with independent variables (age, the time of exposure, and cigarette smoking status) was examined using linear multivariate regression model [Table 5]. Results showed that only "flour exposure" has meaningful linear relationship with all parameters and reduced them.

Furthermore, the relationship between pulmonary respiratory diseases symptoms and age, time of exposure, and cigarette smoking status was all examined using logistic regression model [Table 6]. Results demonstrated that - except the state of exposure and age - other independent variables have no meaningful relationship with the symptoms.

DISCUSSION

Based on the data provided, the two groups under study (exposed and non-exposed) were similar considering demographic features such as mean age, work background, weight, and height [Table 1]. None of the individuals under study had the symptoms of respiratory diseases and chest lesions early in their employment. Examining mean inhalable flour dust concentration (38.773 ± 3.68 mg/m^3), it was determined that the extent of workers dust exposure with the allergen is tens of times further than its authorized threshold that recommended by the American Conference of Governmental Industrial Hygienists (TLV=0.5mg/m^3),[27,39,40] and it is also higher than the occupational exposure limits suggested by Technical Committee of Health Professionals of Iran.[28] As a corollary, based on the observations and results, it is expected that respiratory exposure to flour dust leads to respiratory diseases symptoms (cough, mucus, hoarse breath, chest wheeze, and asthma) outbreak and also the workers' PFC decrease.[18,41,42]

In a study by Fahim and El-Prince, allergic respiratory symptoms were more common in Bakers than in the control group, and they had a significantly higher odds ratio for allergic symptoms and shortness of breath. FVC, FEV_1/FVC, and forced expiratory flow (FEF) percentage parameters were lower in Bakers than in the control group. It was found that occupational exposure to dust not only caused respiratory irritation and allergy but also reduced the values obtained for lung function tests including FVC, FEV_1, FEV_1/FVC, and FEF25–75%.[29,43,44] Moghaddasi *et al*. comparing subjects exposed to dust for <5 years and the control group, no significant difference in terms of FEV_1 and FVC parameters was observed between the two groups. However, comparing with the control group, the mean percentage of FEV_1 and FVC was lower in those with a history of over 5 years of exposure. The results showed that flour dust pollutants had adverse effects (negative) on the main pulmonary parameters (such as FEV_1 and FVC).[30,45,46] Melo *et al*. conducted a study to assess lung function and used the results of spirometry tests to investigate pulmonary function abnormalities in flour factory workers. According to the results, there was a significant reduction in the main pulmonary parameters of the subjects compared to the controls. The results showed that the flour factory workers were exposed to the risk of (recurrent) lung dysfunction.[31] The type of pulmonary

Table 6: The effect of parameters on the prevalence of respiratory symptoms using logistic regression (*n*=176)

Characteristics	Independent variable	Coefficient of B	*P*†	EXP (B)
Cough				
	Age	−0.026	0.162	0.974
	Job experience	0.017	0.530	1.01
	Cigarette	−0.046	0.906	0.955
Sputum				
	Age	−0.029	0.136	0.972
	Job experience	−0.012	0.680	0.988
	Cigarette	−0.110	0.788	0.896
Wheezing				
	Age	−0.018	0.316	0.982
	Job experience	−0.004	0.896	0.996
	Cigarette	−0.079	0.840	0.924
Dyspnea				
	Age	0.001	0.947	1.001
	Job experience	0.014	0.618	1.014
	Cigarette	0.161	0.695	1.174

†Logistic regressions

lesion resulted from flour dust respiration is among chronic obstructive pulmonary diseases.[32,33] In a study by Deshpande *et al*., flour factory workers were affected by the obstructive pulmonary disorder and showed a reduction in their original capacities.[34,47]

The distinctive feature of this pulmonary lesion spirogram was tangible FVC reduction, yet expiratory flow amount expressed by FEV_1 was natural or reduces with the same ratio of FVC, and as a result, FEV_1/FVC ratio remains close to the natural value[35,48-50] which the features correlate with findings of the study, as well. Respiratory diseases symptoms outbreak correlates with the results of Neghab *et al*.,[18] and also other studies.[36,37,51] Pulmonary function capacity reduction is also similar to previous studies.[17-21,38]

Since the exposed group was determined, pulmonary capacities were examined using multivariate regression model to control the variables under study. As observed in Table 5, the quartet had no meaningful effects on the capacities, so it can be concluded that exposure to flour has led to the pulmonary capacity reduction. It relatively correlates with the results of Neghab *et al*.'s study.[18,52]

To control the quartet effect understudy on the extent of respiratory diseases outbreak, two-state logistic regression model was administered. Results showed that flour exposure has induced the demonstration of pulmonary diseases symptoms in the study. It also relatively correlates with the results of Neghab *et al*.'s study.[18] According to the results Deshpande *et al*.,[39] there was a negative relationship between time of exposure and lung function parameters including FVC, FEV_1, FEV_1/FVC, PEFR, and maximum voluntary ventilation. In addition, FEF25–75% parameter did not show a significant decrease.

CONCLUSION

This study shows that excessive dust exposure (higher than the recommended authorized level) results in a meaningful increase of respiratory symptoms and a meaningful decrease of pulmonary function. Hence, to reduce or eliminate the outbreak of the symptoms and also pulmonary function parameter fall in the workplaces under study, technical, and engineering actions (such as suitable ventilation systems), and managerial (exposure time decrease) must be taken.

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