Egyptian Journal of Chest Diseases and Tuberculosis (2013) 62, 745–753

The Egyptian Society of Chest Diseases and Tuberculosis

Egyptian Journal of Chest Diseases and Tuberculosis

www.elsevier.com/locate/ejcdt
www.sciencedirect.com

ORIGINAL ARTICLE

Effects of exposure to flour dust on respiratory symptoms and pulmonary function of mill workers

Hamdy A. Mohammadien [a,*], Mona T. Hussein [a,1], Raafat T. El-Sokkary [b,2]

[a] *Departments of Chest Diseases and Tuberculosis, Sohag Faculty of Medicine, Sohag University, Egypt*
[b] *Departments of Chest Diseases and Tuberculosis, Assuit Faculty of Medicine, Assuit University, Egypt*

Received 18 May 2013; accepted 5 September 2013
Available online 4 October 2013

KEYWORDS

Flour mill workers;
Flour dust;
Respiratory symptom;
Pulmonary function test

Abstract *Objective:* To assess the effect of exposure to flour dust on respiratory symptoms and lung function of flour mill workers and to estimate the additive effect of smoking on pulmonary function.

Patients and methods: This study was carried out at flour mills in Sohag Governorate. Two hundred male workers with current exposure to flour dust and two hundred non-exposed male as a control group were interviewed and self designed study questionnaire was administered to them and the parameters of their pulmonary function were measured.

Results: Respiratory symptoms such as cough, expectoration, wheezing, and shortness of breath, were significantly ($p < 0.0001$) higher among exposed workers as compared to unexposed. Furthermore highly significant ($p < 0.0001$) decrements in the pulmonary function of exposed subjects were noted. Moreover, a highly significant decline in FEV1%, FVC% and FEV1/FVC% was noticed regarding the duration of exposure to flour dust ($p < 0.0001$). Also, there was a highly significant difference between heavily exposed compared to lightly exposed subjects ($p < 0.001$).

The additive effect of smoking was noticed as there was a highly significant decline of FVC%, FEV1%, FEV1/FVC%, FEF25% and FEF75% in smokers compared to non-smokers ($p < 0.0001$).

Conclusion: Flour mill workers in Sohag Governorate, like grain workers elsewhere, were at an increased risk of developing pulmonary symptoms, a strong association exists between exposure to

* Corresponding author. Tel.: +20 01006870068.
E-mail addresses: h_mohammadien@yahoo.com (H.A. Mohammadien), monatahah@gmail.com (M.T. Hussein), Elsokkary100@yahoo.com (R.T. El-Sokkary).
[1] Tel.: +20 01221090439.
[2] Tel.: +20 01006155517.

Peer review under responsibility of The Egyptian Society of Chest Diseases and Tuberculosis.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.ejcdt.2013.09.007

flour dust and the prevalence of respiratory symptoms and functional impairments of the lungs. The result has implications for improved dust control measures in the grain industry in Egypt.

Introduction

The respiratory health effects have been documented in workers exposed to a variety of dusts in small and large-scale industries, which generate dust during their production process. The diseases of the respiratory system induced by occupational dusts are influenced by the type of dust, dose, duration of exposure and genetic factors [1,2]. Occupational diseases are caused by a pathologic response of the patients to their working environment [3]. A threshold limit value of 0.5 mg/m^3 of flour dust was proposed in 2009 by the American Conference of Governmental Industrial Hygienists (ACGIH) as the occupational exposure level (OEL) in breathing zones for workers in flour mills [4].

The American Conference of Governmental Industrial Hygienists (ACGIH) defines flour as a complex organic dust consisting of wheat, rye, millet, barley, oats or corn cereal, or a combination of these, which have been processed or ground by milling [5] and may contain a large number of contaminants including silica, fungi and their metabolites (aflatoxin), bacterial endotoxins, insects, mites, mammalian debris and various chemical additives such as pesticides and herbicides [6]. The gram negative bacterial endotoxins can elicit profound immunotoxic and immunomodulating effects in vitro and in vivo [7] and therefore can exacerbate adverse pulmonary reactions to grain dust. Exposure to flour dust occurs across a range of food industries including grain mills, flour mills and bakeries. The level of dust exposure is highest in the mixing and packing sites of the flour mills [8].

Wheat flour is a complex organic dust with a large diversity of antigenic or allergic components [9]. The antigens involved can be wheat flour proteins, flour parasites, silica, fungi, insects or technical additives such as enzymes [10]. Multiple allergens exist in the protein fraction of wheat flour that are responsible for respiratory dysfunctions and baker's asthma [11,12].Wheat flour consists of water soluble albumins, salt-soluble globulins, gliadins and glutens. Albumins and globulins appear to be the most important proteins contributing to immediate hypersensitivity reactions to wheat proteins [13]. Proteomic studies have shown that gliadin and glutenin account for a high proportion (80%) of the wheat proteins [14,15]. Gliadin and glutenin have also been found effectively implicated in wheat flour-related allergic diseases [16,17]. Accordingly, immunological responses to flour exposure have been reported in bakers and mill workers based on the elevation of serum IgE, IgG and IgA antibodies [18–20].

Flour dust is a hazardous substance; it is a respiratory sensitizer and is known to cause allergic rhinitis and occupational asthma among bakers and millers [21]. Asthma arising from workplace exposure to cereal flour (bakers' asthma) is one of the commonest types of occupational asthma [22,23]. It is also an irritant and may give rise to short term respiratory, nasal and eye symptoms or it may provoke an asthmatic attack in individuals with pre-existing disease and also lead to chronic bronchitis [24]. In addition, flour and / or grain mill workers have been reported to exhibit a variety of clinical manifestations including wheezing, febrile reactions, grain fever, lung fibrosis, allergic alveolitis, impairment of lung function and chronic obstructive pulmonary disease [25,26]. In occupational respiratory disease, spirometry is one of the most important diagnostic tools. Measurement of dynamic lung functions is more important than of static lung volumes. Lung function tests are beneficial in the early recognition of pulmonary dysfunctions even if the workers may be normal clinically [27].

This study was conducted to investigate the effects of exposure to flour dust on respiratory symptoms and lung function of flour mill workers in Sohag, Egypt and to assess the additive effect of smoking on pulmonary function parameters.

Materials and methods

Study population

This study was conducted in the flour mills located in Sohag Governorate, Southern Egypt between March 2009 and November 2011. Two hundred flour mill workers with a mean age of 38.8 ± 11.2 years (range17–66 years), were enrolled in this study. These flour mill workers worked for at least 8–10 h a day for 6 days per week, without using any self-protective measures. In addition, an equal group of unexposed office workers with a mean age of 40.5 ± 9.6 years (range 22–59 years), matched the flour mill workers by sex, age, residence, body mass and social class was studied as a control.

Questionnaire

All subjects were interviewed by a physician who filled the questionnaire. The questionnaire included, among other items, questions on work history, respiratory symptoms, and smoking status of the study subjects. The work histories of the study subjects were assessed through questions on previous and current job, daily working time, job description, working conditions, ventilation conditions, and protective measures used. Respiratory symptoms (cough, phlegm, dyspnea, wheezing, 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 flour. General and local examination of all body systems on emphasize of the respiratory system were carried out for all participants.

Education level: was divided into two groups.

(1) ⩽9 education years (compulsory education).
(2) More than 9 education years.

Smoking index: It was divided into three grades by smoking degree (number of cigarettes smoked daily multiplied by the number of smoking years), according to classification of Nitti [28], we classified smokers into:

Table 1 Characteristics of the study populations.

	Exposed (flour mill workers) (n = 200)		Non-exposed (Control) (n = 200)		P-value
	No	%	No	%	
Age year, mean (range)	38.8 ± 11.2		40.5 ± 9.6		0.110
Height (cm)	169.32 ± 0.74		168.28 ± 0.89		0.12
Weight (kg)	65.31 ± 1.12		64.92 ± 1.19		0.21
Smoking history					–
Smokers	150	75%	70	35%	0.000
Non-smokers	50	25%	130	65%	0.000
Total	200	100%	200	100%	–
Smoking index					–
Mild	10	6.6%	12	17.1%	0.029
Moderate	40	26.6%	16	23%	0.513
Heavy	100	66.6%	42	60%	0.303
Total	150	100%	70	100%	–
Education level					–
⩽9 years	150	75%	40	20%	0.000
>9 years	50	25%	160	80%	0.000
Total	200	100%	200	100%	–
Duration of employment/years	96				–
⩾10 years	104	48%	90	45%	0.670
>10 years		52%	110	55%	0.670

(1) Mild smokers: smoking index less than 200.
(2) Moderate smokers: smoking index (200–400).
(3) Heavy smokers: smokers index more than 400.

Exposure to flour dust: was divided into:

(1) ⩽10 years exposure.
(2) Exposure more than 10 years.

Degree of exposure to flour dust:-

(1) Lightly exposed: individuals working outside flour mill rooms (in offices).
(2) Heavily exposed: individuals working inside flour mill rooms.

Spirometry

Spirometry was performed for all participants using Jaeger Master Screen Diffusion, Viasys Healthcare, GmbH, Hoechberg, Germany. The measured parameters were: forced vital capacity (FVC), forced expiratory volume in one second (FEV1), forced expiratory ratio (FEV1/FVC%) and forced expiratory flow (FEF) at 25%, 50% and 75%, of FVC (FEF 25%, FEF50%, and FEF75%, respectively). The apparatus was calibrated daily and operated within the ambient temperature range of 20–25 °C. The test was performed with the subject in sitting position using a nose clip. The test was repeated three times after adequate rest and results were obtained in the spirometer. The results of spirometer were expressed as percentages of the predicted values according to current guidelines [29].

The research protocol was approved by local ethics committee and written informed consent obtained from each subject prior to inclusion in the study.

Statistical analysis

The statistical analysis and graph formation were done using SPSS version 12. Results are presented as numbers and percentages and mean ± SD standard deviation, and the independent sample t-test was used to compare mean differences. A P-value of less than 0.05 was considered statistically significant.

Results

A total of 400 workers were included in this study, 200 flour milling workers (exposed to flour dust in the work place) and 200 workers (unexposed to such hazard, control group). All workers included in the study were males. The age of the flour milling workers ranged between 17–66 years with a mean of 38.8 ± 11.2 years while the age of the comparison group ranged between 22–59 years with a mean of 40.5 ± 9.6 years. There were significant differences between the two groups with respect to smoking habit and education level but there was no significant difference between the mean age, height, weight and duration of employment of flour mill workers and controls as shown in (Table 1).

Respiratory symptoms were significantly higher in flour mill workers than in controls. A significantly higher prevalence of respiratory symptoms in flour mill workers was related to the shortness of breath, wheezes, productive cough ($p < 0.0001$), also there are highly statistically significant differences for wheezes, crackles, hyperinflation and radiological findings ($p < 0.0001$). Furthermore, a significantly and markedly higher percentage of flour milling workers as

Table 2 Respiratory symptoms, sings and chest diseases in study populations.

	Exposed		Non-exposed		*P*-value
	No	%	No	%	
Respiratory symptoms					
Dry cough	15	7.5	5	2.5	0.120
Productive cough	175	87.5	75	37.5	0.000
Dyspnea (Shortness of breath	120	60	26	13	0.000
Wheezes	145	72.5	30	15	0.000
Chest pain	14	7	6	3	0.194
Clinical chest examination					
Normal	58	29	155	77.5	0.000
Wheezes	120	60	28	14	0.000
Crackles	70	42.5	20	10	0.000
Hyperinflation	70	42.5	18	9	0.000
Chest X ray finding					
Normal	20	10	162	81	0.00
Exaggerated bronchovascular marking	100	50	20	10	0.00
Hyperinflation	70	35	18	9	0.0007
Reticulonodular	10	5	0	0	0.02
Chest diseases					
Ch. bronchitis	60	30	12	6	0.00001
Bronchial asthma	25	12.5	8	4	0.02
COPD	85	42.5	18	9	0.00
IPF	10	5	0	0	0.02

Table 3 Respiratory diseases among flour mill works and the control group.

	Study group (200)		Control group (200)		*P*-value
	No.	%	No.	%	
Bronchial asthma	25	12.5	8	4	0.02
Occupational	20	10	0	0	0.001
Pre-existing	5	2.5	8	4	0.7
Chronic bronchitis	60	30	12	6	0.00001
Occupational	55	27.5	0	0	0.000
Pre-existing	5	2.5	12	6	0.03
COPD	85	42.5	18	9	0.000
Occupational	80	40	0	0	0.000
Pre-existing	5	2.5	18	9	0.07
IPF	10	5	0	0	0.02

compared to the control group showed chronic bronchitis, bronchial asthma and chronic obstructive pulmonary disease (COPD) ($p < 0.00001$). None of the symptomatic controls reported work-related changes in the symptoms (Table 2).

Respiratory diseases of flour mill workers and their matched controls are presented in (Table 3) (Fig. 1). Overall respiratory diseases were significantly higher in flour milling workers than in controls (90 % *vs.* 19%; $P \leqslant 0.0001$). Asthma was diagnosed in twenty-five (12.5%) flour mill workers and in eight (4%) controls, and the difference was statistically significant ($P \leqslant 0.02$). 10% of asthma in mill workers was work-related but asthma in control was pre-existing. Chronic bronchitis was significantly higher in flour mill workers (30% *vs.* 6%; $P \leqslant 0.00001$). None of the controls with chronic bronchitis was work-related. A significantly higher prevalence of chronic obstructive pulmonary disease in mill workers was work-related (40% *vs.* 0.0%; $P < 0.0001$). IPF was diagnosed in 5% of flour mill workers and none of controls with significant difference ($P < 0.02$).

Duration of employment was found to be an important factor that influenced the prevalence of respiratory symptoms. Workers with a longer duration of employment reported a significantly higher prevalence of symptoms (96.2%) than those with shorter duration (83.3%) ($p < 0.002$). Furthermore a highly statistically significant ($P < 0.0001$) association was detected between the presence of respiratory symptoms, site of work (*which determines the level of exposure to flour dust*) and tobacco smoking. The study showed that 96.8% of those with a high level of exposure to flour dust in the workplace (*packing unit*) had respiratory symptoms compared to 66.7% in those with a low level of exposure (*all other units*) and (100%) smokers compared to (60%) nonsmokers. Also a

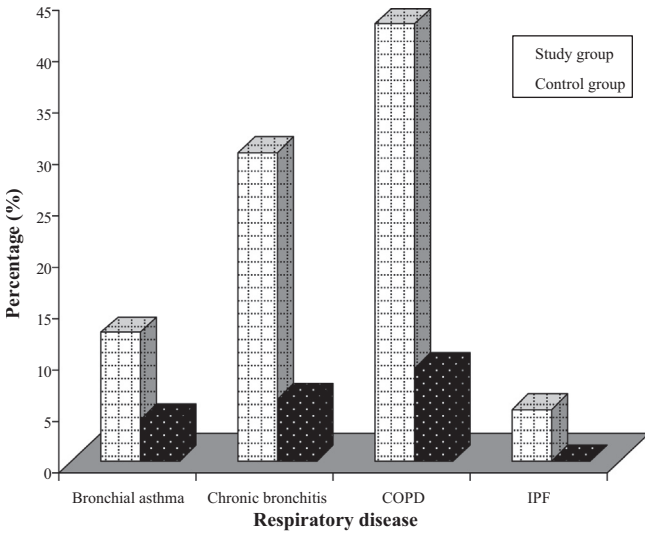

Figure 1 Respiratory diseases among flour mill workers and control group.

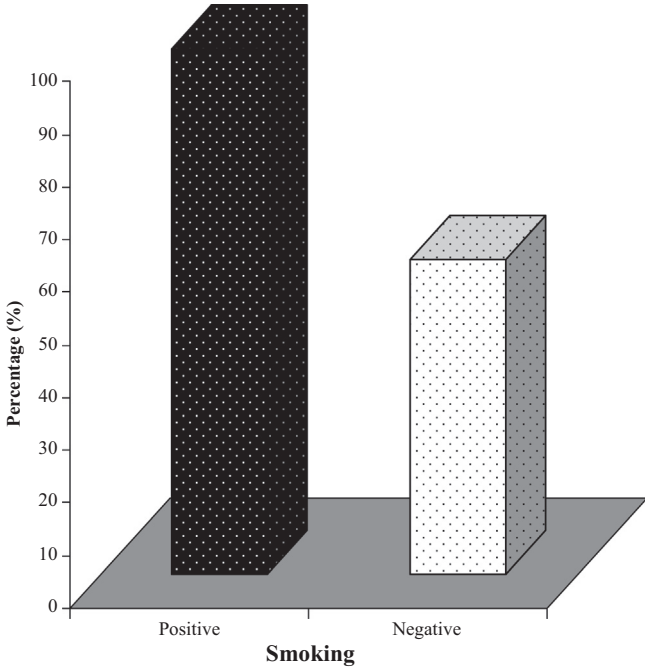

Figure 2 Relation between work related respiratory disorders and smoking.

significant association was found with age 93% of workers <40 who had respiratory symptoms compared to 83.3% of workers >40 years (Table 4) and Figs. 2 and 3.

Flour mill workers had lower FVC%, FEV1%, FEV1/FVC%, FEF25% , FEF50% and FEF75% compared to the controls with highly statistically significant difference ($p < 0.0001$). Moreover there is highly significant decline in lung function parameters in flour mill workers with increasing duration of exposure, a highly significant decline in FVC%, FEV1%, FEV1/FVC%, FEF25%, FEF50% and FEF75% was found in flour mill workers with more than 10 years of exposure when compared with workers with < 10 years of exposure ($p < 0.0001$). Furthermore there are highly statistically significant differences in lung function parameters between smokers and non-smokers ($p < 0.0001$). Regarding degree of smoking there are significant differences in FVC%, FEV1%, FEV1/FVC%, FEF25%, and FEF75% of predicted between mild and both moderate and heavy smokers, also between moderate and heavy smokers ($p < 0.001$). As regards the effect of dust concentration on PFTs there is a highly significant decline in spirometric parameters in heavily exposed flour mill workers compared to lightly exposed subjects ($p < 0.003$) as shown in (Table 5).

Discussion

Flour dust is a heterogeneous substance with respiratory sensitizing and irritating properties; its exposure during milling, transfer operations, mixing and baking processes may induce acute or chronic respiratory ailments, it contains particles from numerous cereal grains (wheat, barley, rye, oats, corn) and may contain a large number of contaminants including silica, fungi and their metabolites (aflatoxin), bacterial endotoxins, insects, mites, mammalian debris and various chemical additives such as pesticides and herbicides [30].

In the present study, all respiratory symptoms were more prevalent among flour mill workers compared to the controls

Table 4 Work-related respiratory disorders among the study group according to selected risk factors.

Risk factors		Total No.	% with symptoms	*P*-value	Significance
Age/years	<40	<140	130 (93%)	0.029	S
	<40	60	50 (83.3%)		
Duration of employment/years	⩽10	96	80 (83.3%)	0.0027	HS
	<10	104	100 (96.2%)		
Smoking	+ve	150	150 (100%)	0.0001	HS
	−ve	50	30 (60%)		
Level of exposure to flour dust (based on site)	High	155	150 (96.8%)	0.0001	HS
	Low	45	30 (66.7%)		

HS: Highly significant $p < 0.01$, <0.001.
S: Significant $p < 0.05$.
NS: Non-significant $p > 0.05$.

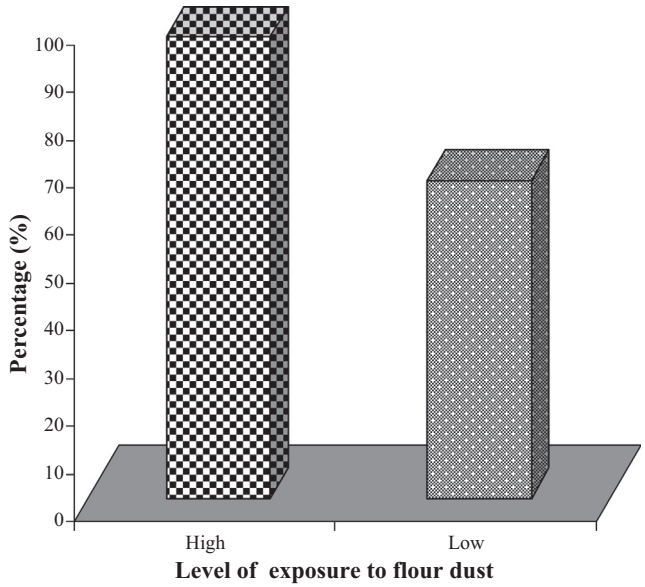

Figure 3 Relation between work related respiratory disorders and level of exposure to flour dust.

and the differences which were highly statistically significant. This is in agreement with many studies carried out on flour mill workers and bakers [5,8,31,32]. In addition, flour mill workers have been reported to exhibit a variety of clinical manifestations, including 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 [33].

Gimenez et al. [34] have observed that flour dust exposure causes cough, phlegm production and the decreased pulmonary function values among flour mill workers compared to their matched controls. Similarly, Bohadana et al. [35] showed that regardless of exposure to relatively low concentration levels of inspirable flour dust, subjects working in the baking industry are at risk of developing respiratory symptoms and airway hyperresponsiveness.

James et al., Ahmed et al. 2009 and Talini et al. [13,36,37] reported an increase in frequency of respiratory symptoms and decreased FEV1 in a group of workers exposed to grain and flour dust. In addition, Von Essen [38] demonstrated that grain dust exposure is a common cause of respiratory symptoms and these workers developed obstructive changes on pulmonary function testing.

Massin et al. [39] demonstrated the relation between dust exposure levels and the respiratory health status of workers in grain and flour mills and observed a dose–response relationship between dust exposure levels and chronic respiratory symptoms, suggesting that exposure to grain and flour dust may lead to chronic bronchitis.

Mijakoski et al., Minov et al., and Karadzinska-Bislimovska et al. [40–42] found a higher prevalence of nasal symptoms in bakers than in office workers with significant difference for runny nose, as well as higher prevalence of respiratory symptoms with significant difference for cough and phlegm. There was significant association between these symptoms and duration of workplace exposure in bakers.

Concerning the present study, the higher prevalence of respiratory symptoms may be explained by relatively prolonged exposure, unhygienic conditions and poorly ventilated work places where the study was carried out. The flour dust particles easily enter the respiratory tract of an exposed person. These particles attach to the inner wall of the respiratory tract and disturb the process of inhalation and exhalation of air. The inner cell wall of the respiratory tract does not accept the foreign particles (flour dust), causing a slight irritation in the respiratory tract which is the primary symptom of respiratory disorder [43].

Table 5 Pulmonary function test of the study population in relation to exposure to flour dust, duration of exposure, degree of exposure, smoking habit and degree of smoking.

The study population	FEV1 % predicted	FVC % predicted	FEV1/FVC%	FEF25% pred	FEF50% pred	EF F75% pred
Exposed (n = 200)	66.4 ± 24.1	72.5 ± 19.1	66.1 ± 15.3	34.3 ± 17.9	40.2 ± 22.7	53 ± 32.3
Non-exposed (n = 200)	83.4 ± 7.4	85.5 ± 9.8	76.4 ± 14.3	47.4 ± 16.4	60.2 ± 23.3	81.8 ± 39.7
P value	< 0.0001	< 0.0001	< 0.008	< 0.0001	< 0.0001	< 0.0001
Exposed ⩽10 years (96)	77.7 ± 17.3	73.3 ± 22.0	73 ± 13.4	40.6 ± 19.2	50.1 ± 22.7	65 ± 31.6
Exposed > 10 years (104)	63.0 ± 19.5	60.3 ± 24.3	65.1 ± 18.1	26.9 ± 12.9	28.5 ± 16.4	38 ± 26.2
P value	< 0.0001	< 0.0001	< 0.006	< 0.0001	< 0.0001	< 0.0001
Level of exposure to flour dust						
Lightly exposed (45)	69.16 ± 18.2	76.3 ± 15	78.4 ± 16.3	45.6 ± 19	51.8 ± 24	67.1 ± 31.4
Heavily exposed (155)	57.8 ± 20.7	67.4 ± 22.6	64.6 ± 15.3	31.1 ± 16.3	37 ± 21.3	49 ± 31.5
P value	< 0.001	< 0.003	< 0.03	< 0.0006	< 0.006	< 0.02
Smokers (150)	59.1 ± 22	67.4 ± 17.4	64.5 ± 17.7	40.8 ± 19.7	52.5 ± 34.1	60.9 ± 28.7
Non-smokers (50)	90.6 ± 13.7	92 ± 11.2	80.2 ± 9.1	61.7 ± 11.5	60.1 ± 35.1	70.8 ± 31
P value	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.05	< 0.05
Degree of smoking						
Mild (10)	96.5 ± 15.3	95.3 ± 15.3	83.4 ± 7.7	54.8 ± 14.1	59.9 ± 37	91.1 ± 6.1
(40) Moderate	81.5 ± 7.6	83.8 ± 7.6	78.4 ± 12	50.9 ± 21.7	53.5 ± 24.6	81 ± 38.4
Heavy (100)	47.1 ± 13.6	58.4 ± 11.8	57.6 ± 15.8	37.9 ± 23.3	60.3 ± 37	65.6 ± 29.1
P value of mild and mod.	< 0.0001	< 0.001	< 0.2	< 0.2	< 0.07	< 0.01
P value of mild and heavy	< 0.0001	< 0.0001	< 0.0001	< 0.002	< 0.7	< 0.007
P value of mod. and heavy	< 0.0001	< 0.0001	< 0.0001	< 0.001	< 0.9	< 0.05

The results of the present study showed a highly statistically significant reduction in the mean values of FVC%, FEV1%, FEV1/FVC%, PEF25%, PEF50% and PEF75% in the flour mill workers as compared with their matched controls as well as directly proportional impairment of their lung function parameters to the duration of exposure to flour. Many authors reported a significant reduction in the overall mean values of FVC, FEV1 and PEFR; in the bakers relative to their matched controls [33,2,32]. Similarly Corzo and Naveda [44] observed spirometric changes due to high concentrations of wheat dust at a wheat processing plant in anthropometrically matched subjects. They reported a decrease in the Peak Flow Rate (PFR), Forced Expiratory Volume (FEV%), Forced Expiratory Flow at 25% ($FEF_{25\%}$), and Forced Expiratory Flow at 75% ($FEF_{75\%}$) and also demonstrated that the longer summative time of exposure to flour dust was associated with more diminished spirometric values.

Chen [45] divided the flour mill workers into heavy-exposure group and light-exposure group and observed that FEV1, FVC, MEF and PEF were significantly decreased in the heavy-exposed group than lightly exposed group. The findings indicated that exposure to high concentrations of dust for a long period of time impairs the pulmonary function. Yach et al. [30] studied grain mill workers and found that the grain mill workers had significantly deteriorated lung function values compared to their matched controls. In addition, Meo [8] and Dhillon and Kaur [46] studied the relationship between dose responses and duration of exposure on the lung function in flour mill workers and observed that FVC, FEV1, PEF and MVV were decreased in flour mill workers compared to their matched controls and this impairment was significantly associated with the increased duration of exposure to flour dust in the flour mills.

Awad et al. [47] also observed a significant decline in the lung function parameters, FVC and FEV1, in workers exposed to flour dust compared to the control group. Our results confirm the results observed by the latter authors [47].

Ige and Awoyemi [48] investigated the occupationally induced lung function impairment in bakery workers as a result of exposure to grain and flour dusts. They reported that the mean values of FVC, FEV1, PEFR, and FEV1/FVC% in the bakery workers were significantly lower than those of the control subjects. Zodpey and Tiwari [49] reported that the PEFR value was significantly reduced in flour mill workers as compared to their controls. The decline in PEFR was linked with dust exposure and its duration. The results of our study are in agreement with the observations made by those authors [47,48].

Post et al. [50] showed an annual decline in forced expiratory volume in one second (FEV1) and maximal mid-expiratory flow (MMEF), these parameters were significantly related to occupational exposure to dust in grain processing and in the animal feed industry.

Karadzinska-Bislimovska et al., Minov et al., and Minov et al. 2010 [42,51,52] reported that spirometric parameters were lower in bakers with significant difference for small airway indices confirming that exposure to dusts, fumes, vapors, or gases is associated with chronic airflow obstruction, predominantly affecting the smaller airways.

In addition, Shamssain [53] observed respiratory symptoms and ventilatory function in nonsmoking flour processing male bakery workers and reported that the exposed group had significantly lower forced expiratory indices than the control group. Mean percent predicted values for forced expiratory volume in one second (FEV1), forced expiratory ratio (FEV1/FVC%), forced mid-expiratory flow (FMF) between 25% and 75% of FVC (FEF25–75%) and peak expiratory flow rate (PEFR) were, respectively, 11.2%, 20.0%, 31.0%, and 36.1% lower in the exposed group compared to controls [53].

Schwartz et al. [54] reported that grain mill workers had significantly reduced spirometric measures of airflow FEV1, FEV1/FVC, and FEF25–75. Zuskin et al. [9] found a significant across-shift reduction in ventilatory capacity in exposed workers, being the largest for flow rates at 50% and the last 25% of the vital capacity on maximum expiratory flow-volume (MEFV) curves (FEF50, FEF75). These data suggest that workers employed in the processing of flour may be at a risk for the development of respiratory impairment.

Our study found that there was a statistically significant association between work-related respiratory disorders and duration of employment, site of work (which determines the level of exposure to flour dust) and age. This is in agreement with Ajeel & Al-Yassen [31] and Karjalainen et al. [55] who found that the longer the duration of employment the higher the prevalence of allergic symptoms. It is interesting to note that advanced age was not associated with symptoms suggesting that these symptoms are related to irritation and sensitization to flour particles at workplace rather than to chronic permanent damage. A study in India found that age had no influence on the incidence of cough and rhinitis in bakery workers, however, age significantly influenced the incidence of breathlessness [56]. Another finding in our study is that there was a significant association between work-related respiratory disease and tobacco smoking. Singh et al. [56] found that smoking habit influenced significantly the incidence of cough but had no direct effect on breathlessness and rhinitis. On the other hand Ajeel and Al-Yassen [31] reported that there was no evidence of significant association between allergic symptoms and tobacco smoking.

Mijakoski et al. [40] reported that BHR in bakers was significantly associated with duration of employment at the actual workplace and daily smoking that suggests that duration of workplace exposure and smoking additively contribute to the development of BHR.

Some investigators have reported normal pulmonary function in workers exposed to flour dust. Kakooei1 and Marioryad [57], demonstrate that there are no significant differences between the ventilatory function test results of the flour mill workers and control subjects.

In conclusion

The present study confirms the findings of others and suggests that occupational exposure to flour dust could cause respiratory irritation and sensitization; and reduction in the pulmonary function parameters, such as FVC%, FEV1%, FEV1/FVC%, FEF25%, FEF50%, and FEF75%. Moreover, the present study revealed a dose response relationship between pulmonary function tests and duration of exposure to flour, among flour mill workers. The findings are of importance in that they demonstrate the extensive need for preventive measures and show the magnitude of the effect in a survivor

population. It is advisable therefore, that flour mill managers, their workers and health officials should work together to adopt technical preventive measures, such as having well ventilated work areas, workplace hygiene, health education programs and wearing appropriate respiratory protective devices. These measures will help to prevent lung damage, which often, over time, contributes to morbidity and mortality. It is also suggested that flour workers must undergo pre-employment and periodic medical surveillance tests (spirometry and SPT examination). These tests will identify susceptible workers, so that they can take adequate preventive measures as well as medication.

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