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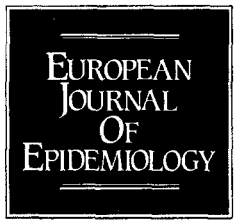

RESPIRATORY FUNCTION IN FLOUR-MILL WORKERS

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The frequency of bronchial symptoms and the alteration of respiratory function parameters were studied in a group of 63 workers of an industrial flour-mill, and in a control group matched according to age, social class, and tobacco intake. In the exposed group the answers to a questionnaire indicated a greater incidence of cough ($p<0.01$) and chronic expectoration ($p<0.01$) as well as clinical airway hyperreactivity ($p<0.01$). No differences were noted for either asthma or allergy. The respiratory function parameters did not differ between the two groups studied. These results suggest that workers exposed to the vegetable dust found in fluor-mills are subject to develop chronic bronchial irritation.

INTRODUCTION

Ever since the time of Ramazini's observations (21), attention has been drawn to the frequency of respiratory symptoms, abnormalities of respiratory function and bronchial reactivity among workers exposed to cereal dust. This work environment contains numerous biological and chemical pollutants to which other risk factors (i.e. tobacco) are added. Mill work has not inspired many epidemiological studies although the allergic symptoms of bakers have attracted the clinician's attention. Still, mill-dust is more specific and concerns essentially one type of cereal: wheat. In addition, this type of work is divided into very specific operations, allowing a precise inventory of the characteristics for each work site. Our goal was to study the prevalence of clinical symptoms and abnormalities in respiratory function in an industrial flour mill.

POPULATION, MATERIAL AND METHODS

Population

A. The survey involved 136 workers, 82.4% of the available work force in an industrial flour mill. In order to be able to follow them for 5 years we retained, for the analysis, only subjects who were less than 50 years old (N = 63). They constituted the exposed population.

Subjects came from 4 different work sites within the mill: grain reception, silo filling, flour bagging, and animal food bagging.

Female workers were not studied since their small number made it difficult to constitute a control group.

B. As it was impossible to find valid control subjects in the factory, the control group belonged almost exclusively (92%) to the Bordeaux hospital (kitchen, maintenance, workshop, linen room)

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staff. The remaining 8% were members of mill's administrative staff who were not exposed to dust (drivers, switchboard operators, computer personnel).

C. The two groups were matched according to age (± 5 years), social class (based on their professional qualification), and smoking habits. They were separated into three groups:

— smokers (at least one cigarette a day for a year);

— former smokers (having stopped smoking at least 6 months prior to the study);

— non-smokers.

Questionnaire

The questionnaire was developed from the MRC and CECA. It was based on a modification of the French study PAARC questionnaire (14).

The questions concerned the usual bronchial symptoms (cough, chronic expectoration, dyspnea, asthma, bronchial wheezing), allergy and symptoms suggesting airway reactivity (rhinitis, sneezing, bronchial wheezing when exposed to a smokey environment, to cold air or to the work environment after the week-end break). In addition, the questionnaire also included questions on the subject's each person's professional career and conditions of the exposure. The questionnaire was administered to all subjects on the work site by the same trained interviewers.

Study of the respiratory function

We used a computerised spirometer. We traced a flow/volume curve and measured the forced expiratory volume in one second (FEV1), the maximum mean expiratory flow rate between 25% and 75% of the forced vital capacity (MMEF 25-75), the maximum expiratory flow at 25%, 50%, and 75% of the forced vital capacity (MEF 25, MEF 50, MEF 75). The residual volume (RV) was measured with the diluted helium technique.

Spirometric measurements were performed on the work site. At least 3 readings were obtained in order to realise 2 reproducible curves.

Aero-biology of the professional environment

A. Quantitative analysis

The average concentration of global dust (organic or mineral) was measured for each work site by filtration of 10 to 140 m^3 of air (80 m^3 an hour).

B. Qualitative analysis

The microbiological study was established using two methods:

— sedimentation on Petri dish and two kinds of culture: standard Agar for aerobic bacteria and Agar malt for yeast and moulds. The results were converted into CFU numbers (colony forming units) deposited on 63.5 cm^2 per 15 min period.

— Impaction on solid environment by surface air system. The results are given in number of CFU/m^3. A microscopic study of dust suspended in the air was also made after sampling on an EGAI impactor that allows the selection of particles according to their diameters (>5, 5 to 2, 2 to 1, 1 to 0.7, 0.7 to 0.3 μ). Each sample was observed at 250 and 400 magnification.

Computer processing and statistical analysis

After matching, the dependancy between two variables was studied by Chi^2 test and the means of the ventilatory function values were compared using a « t » test. The Yates correction was applied for the small populations.

RESULTS

Demographic characteristics of both populations

The main characteristics of both populations are summarized in Table 1. For the exposed subjects who smoked (n = 41), the tobacco intake at the time of the survey varied from 5 to 50 cigarettes a day, with an average of 21 ± 11 cigarettes per day. For the smokers of the control group, the tobacco intake varied from 2 to 50 cigarettes a day, with an average of 16 ± 11 cigarettes a day.

TABLE 1.
Demographic data.

	Flour mill workers		Control Group	
Number of subjects	63		63	
	n	%	n	%
19-30 years	22	35	22	35
31-40	16	25	16	25
41-50	25	40	25	40
Non Smokers	12	19	12	19
Ex Smokers	10	16	10	16
Smokers	41	65	41	65
Employment years				
>6 months ≤5 years	28	44		
>5 years	35	56		

Dust concentration

A. Quantitative analysis

The percentage of dust varied from 2.3 mg/m³ in the area where animal food was bagged, to 8.1 mg/m³ in grain reception, 15.8 mg/m³ in the silo filling area and 124.8 mg/m³ in the flour bagging zone.

B. Qualitative analysis

— Mycological analysis of the air:

This analysis revealed mycological contamination at the various work places, essentially made of *Penicillium* and *Cladosporium;* no *Aspergillus fumigatus* was present.

— Microscopic analysis of the dust sample:

No traces of mites were found. For the most part, the dusts were vegetable, composed primarily of wheat starch. Their particle sizes varied according to work site, with a prevalence of particles greater than 1 µ where the flour was packaged and where the grain was unloaded. At the other work places the particles were smaller.

Symptom prevalence (tables 2 and 3)

For the following questions, the answers we obtained were statistically different between the exposed and non-exposed subjects:

— Do you usually cough at night, or when you get up, or in the winter during the day? ($p<0.01$).

— Do you usually expectorate during the day or at night or in the winter? ($p<0.01$).

— Have you experienced coughing or expectoration that lasted 3 weeks or more during the last 3 years? ($p<0.05$).

— Do your working conditions usually provoke nose or throat irritation, or respiratory difficulty? ($p<0.01$).

Do you experience any of the following symptoms: cough, runny nose, wheezing when you walk into a smoky room? When you walk outside into the cold? When you return to work after the week-end? ($p<0.01$). The most important factors were contact with cold air and the first day back at work after the week-end. This was true regardless of the age of the worker.

There were no significant differences between the exposed group and the control group for questions concerning dyspnea, wheezing, asthma and allergic spmptoms, pathological pulmonary history, the occurrence of acute bronchitis or sick leave for respiratory problem during the last 12 months. The same holds true when a person changes work place because of respiratory problems or when a person takes sick leave following the inhalation of dust, or smoke. Finally, there were no significant differences in symptom prevalence according to work duration.

TABLE 2.
Prevalence of respiratory symptoms.

Number of subjects	Flour mill workers 63		Control Group 63		
	n	%	n	%	p
Chronic cough	23	37	8	13	<0.01
Chronic day/night phlegm	11	18	2	3	<0.01
Cough/Phlegm >3wks for 3 years	19	30	9	14	<0.05
Dyspnea	19	30	16	25	<0.01
Wheezing	19	30	17	27	NS
Other symptoms at work (nose, throat irritation, breathlessness)	38	60	16	25	<0.01
Allergy					
Rhinitis	16	25	14	23	NS
Urticaria	10	16	6	5	NS
Eczema	5	8	4	6	NS

TABLE 3.
Symptoms of hyperreactivity.

Number of subjects	Flour mill workers 63		Control Group 63		
	n	%	n	%	p
Tobacco smoke					
— cough	12	19	12	19	NS
— rhinitis	2	3	1	2	NS
— wheezing	2	3	1	2	NS
Cold air					
— cough	9	14	1	2	<0.01
— rhinitis	9	14	4	6	NS
— wheezing	2	3	1	2	NS
1st day at work					
— cough	7	11	0	0	<0.01
— rhinitis	4	6	1	2	NS
— wheezing	1	2	0	0	NS
Cumulative prevalence (1 symptom at least)	30	48	15	24	<0.01

Respiratory function (table 4)

There were no significant differences between the exposed subjects and the control subjects. The same thing was noted if we compared the two groups according to their different smoking habits.

Influence of work place

For the most part, neither the symptoms nor the respiratory function parameters differed sig-

TABLE 4.
Respiratory function data.

	Flour mill workers		Control Group	
	Obs.	% pred.	Obs.	% pred.
FVC (L)	4.67±0.71	99±12	4.79±0.95	99±15
FEV1 (L)	3.84±0.65	104±15	3.96±0.84	104±16
MMEF 25-75 (L · sec^{-1})	4.12±1.51	104±40	4.02±1.28	100±26
PEFR (L · sec^{-1})	8.08±2.7	91±26	8.2 ±2.9	91±23
MEF 25 (L · sec^{-1})	7.4 ±1.9	91±23	7.5 ±2	93±24
MEF 50 (L · sec^{-1})	5.3 ±1.7	94±29	6.4 ±1.6	96±25
MEF 75 (L · sec^{-1})	2.2 ±1.1	102±45	2.2 ±1	102±38
RV (L)	1.6 ±0.5	107±33	1.7 ±0.6	109±42

nificantly from one work site to another. Cough and rhinitis upon return from the week-end break was more common in workers from the grain reception area ($p < 0.01$, and $p < 0.05$ respectively).

Influence of tobacco intake

Tobacco intake was taken into account as we matched the two groups in order to avoid its confounding effect. Nevertheless, it was interesting to verify whether the effects we observed had been modified by smoking.

The small size of the groups and the lack of statistical differences concerning symptoms and respiratory function between smokers (n = 12) and former smokers (n = 10), compelled us to put them into the same group to compare with smokers (n = 41).

We observed that:

— the exposed group coughed more frequently than the control group, regardless of whether they smoked or not;

— the exposed group smokers expectorated more frequently than the control group smokers ($p < 0.05$);

— for non-smokers, the cough/expectoration syndrom for 3 weeks or more was more frequent in the exposed group ($p < 0.05$);

— the exposed subjects who smoked experienced significantly higher hyperreactivity symptoms than control group smokers ($p < 0.01$);

— the symptoms experienced at work were more frequent for the exposed subjects than for the control group whether they smoked or not ($p < 0.01$).

When we compared the respiratory function of smokers and non-smokers according to their risk exposure, we noted that:

— in the control group there was a « tobacco effect » which decreased the MEF 25, MEF 50, and MEF 75 for smokers, as opposed to non-smokers (respectively $p < 0.05$, $p < 0.01$, $p < 0.05$);

— in the exposed group there was no « tobacco effect ».

DISCUSSION

These results show that some respiratory symptoms have a higher statistical occurrence in the exposed group than in the control group.

Cough, expectoration, or respiratory strain at work for the exposed group has been reported by other authors (3, 10, 11, 15, 19, 20, 24). But we have not seen the differences reported for wheezing (10, 11, 15) or dyspnea (10, 11). We were unable to find a relationship between the occurrence of symptoms and the duration of exposure (7, 8, 13, 18).

The significant differences that we noticed concerning the irritation symptoms induced by the exposure to different environments seem to show a bronchial hyperreactivity. Although allergic bronchial challenges with grain dust have seldom been undertaken, some authors have tried to investigate this bronchial hyperreactivity and have noticed an increase in bronchial hyperreactivity to histamine for non-smoker grain workers (18). In the same manner, a decrease in the peak flow during the work day was noticed among grain workers (as opposed to controls) (12, 17); this decrease was associated with the symptom occurrence (6).

The high dust rates to which the workers were subjected are not recent, because the rates measured at grain reception, silo filling, and animal food bagging in 1969 varied between 16.8 mg/m^3 to 31.2 mg/m^3. These rates are far superior to the norms that are usually admitted. The studies of DoPico (11) and Chang Yeung (5) have found a significantly increased frequency of respiratory symptoms in subjects exposed to lower dust rates than the ones we observed.

In spite of the analogy between mills and bakeries, we have not found the high percentage of allergic symptoms frequently found in bakeries (16). This discrepancy cannot be explained on the basis of the difference in the number of subjects examined in the 2 studies. In his study of 80 grain-workers, a population very similar in number to our own, Cockroft obtained results that were comparable to those of the long DoPico series (10, 11).

As far as the selection effect is concerned, it is a bias which exists in all transversal studies: a certain number of exposed subjects escape consideration. Cough, expectoration, and eye irrita-

tion appear very soon after work in the mill begins, causing some workers to leave their jobs and others to change work sites. This phenomenon has been observed in the present study and in all similar investigations previously published as well. It cannot explain, however, the differences that we observed.

An analysis of the company's job turn-over revealed few resignations; in fact, a general stability of the work force down through the years was observed.

This suggests that the dust from flour mills is different from the grain dust that has usually been studied. This could explain the respiratory characteristics of our population. Still, the respective responsabilities of professional exposure and tobacco consumption can be discussed. Are they additive?

In our study, tobacco consumption interferes with the consequences of dust exposure, but, according to the symptoms, it has different effects.

Whether they smoked or not, the exposed subjects coughed more frequently than those of control group. The dust would appear to be an additional bronchial irritant that induces a defense mechanism in the airway.

While cough and/or chronic expectoration are more frequent in exposed non-smoking subjects than in their control group counterparts, this difference disappears for smokers. In this case, the dust seems to produce a « tobacco like » effect.

Dust does not modify the hyperreactivity felt by the non-smokers as opposed to the control group, whereas for smokers there is a difference between exposed subjects and control subjects; tobacco has its own effect for this symptom.

It is clear that the boundary between the effects of tobacco smoke and mill dust is somewhat ambignans. These two agents probably act on the bronchi in different manners, and we should be careful before attributing one symptom to the job environment.

The existance of a link between professional exposure to mill dust and respiratory function impairment has often been debated. Unlike Chang Yeung (4, 5, 23) we found no significant differences between the respiratory function parameters of the two groups we observed. This finding may be related to the nature of the dust in our study, but given the percentage of smokers in each group, it is also possible that the effect of the dust was masked by that of tobacco. If we take the tobacco factor into account, we see that for the non-smokers a difference appears in the parameters reflecting the small and mid-expiratory track function. This difference demonstrates the pernicious effect of this type of environment. Besides, while the control group shows a statistical difference between smokers and non-smokers concerning the bronchial flow at low pulmonary volume, this difference disappears for the exposed group, confirming the « tobacco like » effect of this environment.

It therefore seems that flour mill dust impairs non-smokers' respiratory tracts in the way that tobacco does in smokers.

CONCLUSION

This study shows that the prevalence of cough, expectoration, and respiratory tract hyperreactivity is superior in flour mill workers than in the control group. But if this particular environment acts as a respiratory tract irritant and has a « tobacco like » effect, it seems to be less toxic for the respiratory tract than the environment on grain workers.

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