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Respiratory and Nasal Symptoms, Immunological Changes, and Lung Function in Industrial Bakers

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Abstract

Background: Several studies reported that occupational exposure in bakery may cause respiratory impairment in exposed workers.

Aim: To assess the respiratory effects and immunological changes of occupational exposure in industrial bakers.

Material and Methods: We performed a cross-sectional study including 43 industrial bakers (20 males and 23 females, aged 34-55 years) and an equal number of office workers, matched by sex, age and smoking status. Evaluation of examined subjects included completion of questionnaire, skin prick tests to common and work-related inhalant allergens, spirometry, and histamine challenge.

Results: We found higher prevalence of nasal symptoms in the last 12 months in bakers with significant difference for runny nose ($P = 0.033$). Prevalence of respiratory symptoms in the last 12 months was also higher in bakers and statistical significance was obtained for cough ($P = 0.041$) and phlegm ($P = 0.023$). We found similar prevalence of allergic sensitization to common inhalant allergens in both examined groups, while sensitization to wheat flour and meal flour was registered only among bakers. Measured spirometric parameters were lower in bakers with significant difference for MEF_{50} and MEF_{75} ($P = 0.004$, and $P = 0.000$, respectively). Prevalence of bronchial hyperresponsiveness (BHR) was non-significantly higher in bakers with significantly higher severity ($P = 0.029$).

Conclusion: Our findings confirm that occupational exposure in industrial bakers may lead to adverse respiratory effects and immunological changes in exposed workers.

Introduction

Bakery is a widespread occupation in which millions workers worldwide are employed. Bakeries can be industrial or traditional, flour manipulation can be automatic or manual, and different types of flour can be used in bread and pastry production (e.g. wheat, rye, meal, barley, soy, etc).

On the other side, working in bakery is associated with health risks, primarily for respiratory impairment. A variety respiratory effects have been described among bakers, including asthma, chronic obstructive pulmonary disease (COPD), impairment of pulmonary function, etc [1-5]. Bakers' asthma represents the first cause of occupational asthma in France and one of the most current etiologies in countries of Western Europe [6, 7].

In the present study we aimed at the assessment of prevalence of respiratory and nasal symptoms, lung function effects and immunological changes in industrial bakers.

Material and Methods

Study design and setting

A cross-sectional survey was carried out at the university research laboratory, i.e. Department of Cardiorespiratory Functional Diagnostics at the Institute for Occupational Health of R. Macedonia, Skopje - WHO Collaborating Center for Occupational Health and GA^{2}LEN Collaborating Center between October 2010 and April 2011. Prevalence of respiratory and nasal symptoms and allergic sensitization to common and workplace inhalant allergens, mean values of spirometric parameters, as well as prevalence and severity of BHR were compared between a group of industrial bakers and a group of office workers.

Subjects

We examined 43 subjects (20 males and 23 females) aged 34 to 55 years working as industrial bakers with duration of employment 10 to 23 years. They worked in three working shifts and each of them lasted 8 hours. Their unit consisted of two large closed working areas with central ventilation system. The process of flour manipulation included automatic operations such weighting flour for bread and pastry production, loading flour in mixer, mixing, dividing and shaping dough into pieces and moulding dough pieces. The workplace exposure included flour dust (i.e. wheat, meal, and rye flour) and substances added during bread and pastry making process (alpha-amylase, bakers' yeast, soy lecithin, etc.), as well as flour contaminants (storage mites and moulds). The process control provided keeping of the exposures at the permissible levels. The protective equipment during the working process included protective clothing, gloves, and masks.

In addition, an equal group of office workers matched to bakers by sex, age, and daily smoking was studied as a control.

The subjects with chronic respiratory disease diagnosed by physician (i.e. asthma, COPD, bronchiectasis, etc.) were excluded from the study. In either group there were no subjects in whom histamine challenge was contraindicated [8, 9], nor there were subjects with the respiratory viral infection within three weeks before the challenge test was performed. None of the subjects took antihistamines at least one month before the challenge test and skin prick tests. Daily smokers were asked to restrain from smoking at least 3 hours before testing. All study subjects were informed about the study and their written consent was obtained.

Questionnaire

All subjects were interviewed by a physician who filled the questionnaire. The questionnaire included, among other items, questions on work history, respiratory symptoms in the last 12 months, 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 in the last 12 months (cough, phlegm, dyspnea, wheezing, and chest tightness) were documented using the European Community for Coal and Steel questionnaire (ECCS-87), and the European Community Respiratory Health Survey (ECRHS) questionnaire [10, 11]. Nasal symptoms in the last 12 months (sneezing, itching, runny nose, and blocked nose) were also evaluated.

Classification of smoking status was done according to the World Health Organization (WHO) guidelines on definitions of smoking status [12].

Daily (current) smoker was defined as a subject who smoked at the time of the survey at least once a day, except on days of religious fasting. In daily smokers lifetime cigarette smoking and daily mean of cigarettes smoked were evaluated. Pack-years smoked (one pack-year denotes one year of smoking 20 cigarettes per day) were calculated according to the actual recommendations [13].

Ex-smoker was defined as a formerly daily smoker, no longer smokes.

Passive smoking or exposure to environmental tobacco smoke (ETS) was defined as the exposure of a person to tobacco combustion products from smoking by others [14].

Skin prick tests

Skin prick tests (SPT) to common inhalant allergens and workplace allergens were performed in all subjects on the volar part of the forearm using commercial allergen extracts (Torlak, Serbia) of birch (5000 PNU), grass mixed (5000 PNU), plantain (5000 PNU), fungi mixed (4000 PNU), *Dermatophagoides pteronyssinus* (3000 PNU), dog hair (4000 PNU), cat fur (4000 PNU), and feathers mixed (4000 PNU), as well as of wheat flour (1:20 V/V) and meal flour (1:20 V/V). All tests included

positive (1 mg/mL histamine) and negative (0.9% saline) controls. Prick tests were considered positive if the mean wheal diameter 20 min after allergen application was at least 3 mm larger than the size of the negative control [15]. Atopy was defined as the presence of at least one positive SPT [16].

Spirometry

Spirometry, including measures of forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), FEV_1/FVC ratio, and maximal expiratory flow at 50%, 75%, and 25-75% of FVC (MEF_{50}, MEF_{75}, and MEF_{25-75}, respectively), was performed in all subjects using spirometer Ganshorn SanoScope LF8 (Ganshorn Medizin Electronic GmbH, Germany) with recording the best result from three measurements the values of FEV1 of which were within 5% of each other. The results of spirometry were expressed as percentages of the predicted values according to the European Community for Coal and Steel (ECCS) norms [17].

Histamine challenge

The histamine challenge test was performed according to the actual European Respiratory Society (ERS)/American Thoracic Society (ATS) recommendations [8, 9]. Concentrations of 0.5, 1, 2, 4, and 8 mg/ml histamine (Torlak, Serbia) were prepared by dilution with buffered saline. The doses of aerosol generated by Pari LC nebulizer with output rate 0.17 ml/min were inhaled by mouthpiece. Subjects inhaled increasing concentrations of histamine using a tidal breathing method until FEV_1 fell by more than 20 % of its base value (provocative concentration 20 – PC_{20}) or the highest concentration was reached.

Statistical analysis

SPSS version 11.0 for Windows was used for data description and analysis. Continuous variables were expressed as mean values with standard deviation and categorical variables as numbers and percentages. The chi-square test (or Fisher's exact test where appropriate) was used for testing differences in the prevalence of respiratory and nasal symptoms, the prevalence of allergic sensitization to common inhalant allergens and workplace allergens, as well as in the prevalence of BHR. Comparison of spirometric measurements and BHR severity (expressed as mean PC20) was performed by independent-samples *T*-test. Association between different variables was tested with chi-square test. A *P*-value of less than 0.05 was considered statistically significant.

Results

Characteristics of the subjects enrolled in the study are given in Table1.

Table : Demographics of the study subjects.

Variable	Bakers (n = 43)	Office workers (n = 43)
Males/females ratio	0.9	0.9
Mean age (years)	44.7 ± 6.7	43.9 ± 7.4
Mean duration of employment at the actual workplace (years)	14.1 ± 4.2	15.2 ± 5.7
< 14 years	19 (44.2%)	21 (48.8%)
> 14 years	24 (55.7%)	22 (51.1%)
Smoking status		
Daily smokers	15 (34.9%)	13 (30.2%)
Pack-years smoked	11.9 ± 3.9	12.8 ± 3.2
Ex-smokers	3 (6.9%)	5 (11.6%)
Passive smokers	9 (20.9%)	7 (16.3%)
Accompanying disease		
Arterial hypertension	7 (16.3%)	10 (23.2%)
Diabetes mellitus type 2	5 (11.6%)	6 (13.9%)
Peptic ulcer	4 (9.3%)	4 (9.3%)

Numbers (%) are given, unless otherwise stated.

Prevalence of nasal symptoms in the last 12 months was higher in bakers than in office workers with statistical significant difference for runny nose (Table 2). Runny nose in bakers was significantly associated with duration of employment (*P* = 0.026).

Table 2: Prevalence of nasal symptoms in the last 12 months in examined groups.

Nasal symptoms in the last 12 months	Bakers (n = 43)	Office workers (n = 43)	*P*-value*
Any nasal symptom	18 (41.8%)	11 (25.6%)	0.076
Sneezing	6 (13.9%)	4 (9.3%)	0.256
Itching	7 (16.3%)	4 (9.3%)	0.094
Runny nose	14 (32.6%)	6 (13.9%)	0.033
Blocked nose	7 (16.3%)	5 (11.6%)	0.117

Data are expressed as number and percentage of study subjects with certain variable. * Tested by chi-square test or Fisher's exact test where appropriate.

Prevalence of respiratory symptoms in the last 12 months was higher in bakers than in office workers with statistical significant difference for cough and phlegm (Table 3).

Cough in bakers was significantly associated with duration of employment (*P* = 0.037) and daily

Table 3: Prevalence of respiratory symptoms in the last 12 months in examined groups.

Respiratory symptoms in the last 12 months	Bakers (n = 43)	Office workers (n = 43)	*P*-value*
Any respiratory symptom	16 (37.2%)	10 (23.2%)	0.087
Cough	12 (27.9%)	5 (11.6%)	0.041
Phlegm	6 (13.9%)	2 (4.6%)	0.023
Dyspnea	5 (11.6%)	4 (9.3%)	0.174
Wheezing	6 (13.9%)	5 (11.6%)	0.318
Chest tightness	4 (9.3%)	6 (13.9%)	0.114

Data are expressed as number and percentage of study subjects with certain variable. * Tested by chi-square test or Fisher's exact test where appropriate.

smoking ($P = 0.044$). Phlegm in bakers was significantly related also to duration of employment ($P = 0.028$) and daily smoking ($P = 0.009$). Phlegm in office workers was significantly associated with daily smoking ($P = 0.042$).

Table 4: Prevalence of sensitization to common inhalant allergens in examined groups.

Common inhalant allergen	Bakers (n = 43)	Office workers (n = 43)	*P*-value*
Any common inhalant allergen	15 (34.9%)	16 (37.2%)	0.414
Birch	4 (9.3%)	6 (13.9%)	0.256
Grass mixed	7 (16.3%)	6 (13.9%)	0.219
Plantain	4 (9.3%)	5 (11.6%)	0.308
Fungi mixed	6 (13.9%)	5 (11.6%)	0.281
Dermatophagoides pteronyssinus	10 (23.2%)	9 (20.9%)	0.397
Dog hair	4 (9.3%)	3 (6.9%)	0.359
Cat fur	5 (11.6%)	3 (6.9%)	0.092
Feathers mixed	3 (6.9%)	2 (4.6%)	0.313

Data are expressed as number and percentage of study subjects with certain variable. * Tested by chi-square test or Fisher's exact test where appropriate.

Prevalence of sensitization to common inhalant allergens was similar in both examined groups. Mite sensitization was detected as the most important individual common inhalant allergen among atopic subjects in both groups (Table 4).

Table 5: Mean values of spirometric parameters in examined groups.

Spirometric parameter	Bakers (n = 43)	Office workers (n = 43)	*P*-value*
FVC (% pred)	88.4 ± 8.9	90.3 ± 10.7	0.108
FEV_1 (% pred)	84.8 ± 9.7	86.1 ± 8.1	0.136
FEV_1/FVC%	75.2 ± 4.3	76.3 ± 3.3	0.122
MEF_{50} (% pred)	54.8 ± 9.2	67.1 ± 7.8	0.004
MEF_{75} (% pred)	50.9 ± 7.4	63.2 ± 8.3	0.000
MEF_{25-75} (% pred)	67.3 ± 11.9	71.8 ± 10.4	0.059

Data are expressed as mean value with standard deviation. FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second; MEF_{50}, MEF_{75}, MEF_{25-75}, maximal expiratory flow at 50%, 75%, and 25-75% of FVC, respectively; % pred, % of predicted value.

Allergic sensitization to wheat flour and meal flour was registered only in bakers (11.6% and 4.6%, respectively). There was significant association between both sensitization to wheat flour and meal flour to atopy ($P = 0.017$ and $P = 0.031$, respectively).

Mean values of spirometric parameters were lower in bakers with significant difference for MEF_{50} and MEF_{75}, whereas difference in the mean values of MEF_{25-75} just missed statistical significance (Table 5).

Prevalence of BHR was higher in bakers but statistical significance was not reached (Figure 1). BHR in bakers was significantly related to duration of employment ($P = 0.031$) and daily smoking ($P = 0.039$). BHR severity, expressed as mean PC_{20}, was significantly higher in bakers (Figure 2).

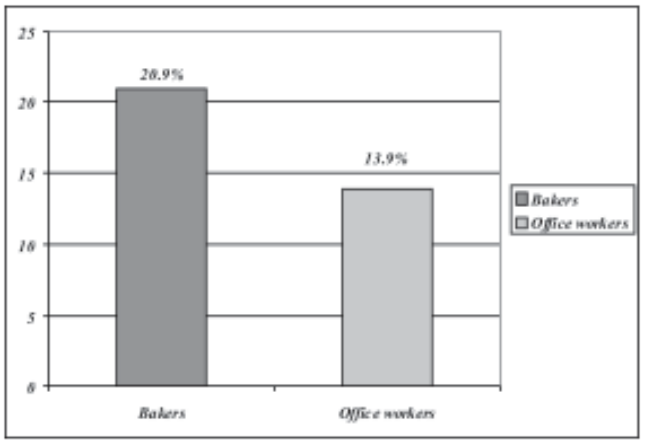

Figure 1: Prevalence of BHR in examined groups: 20.9% vs. *13.9%,* P *= 0.078. BHR, bronchial hyperresponsiveness.*

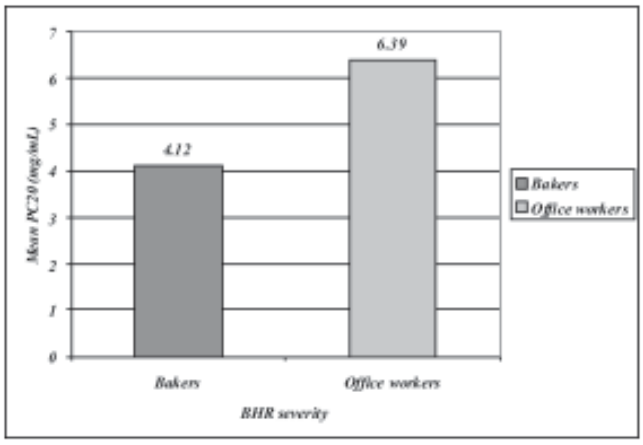

Figure 2: BHR severity in examined groups: (4.12 mg/mL vs. *6.39 mg/mL,* P *= 0.029). BHR, bronchial hyperresponsiveness.*

Discussion

Despite improvement in the implementation of preventive measures, results of actual studies indicate that workplace exposure in bakery and pastry sectors is still associated with adverse respiratory effects in an important proportion of exposed workers [7, 18].

In the present study we compared prevalence of respiratory and nasal symptoms, allergic sensitization to common inhalant and workplace allergens, spirometric parameters, as well as prevalence and severity of BHR in a group of industrial bakers working in conditions of exposure kept at the permissible levels and a group of office workers matched by sex, age, and daily smoking. Demographic characteristics were similar in both groups. A large proportion of daily smokers and passive smokers found in both groups were similar to the ones documented in our earlier studies [19, 20]. The low number of ex-

smokers in both groups suggests that not enough was being done to encourage workers to stop smoking.

We found 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. These findings are complementary with findings from our previous studies on workers exposed to various types of organic dust [21, 22].

The prevalence of allergic sensitization to common inhalant allergens was similar in both examined groups. The pattern of allergic sensitization to common inhalant allergens in the examined groups was comparable to that we had previously observed among adults in R. Macedonia [23, 24]. Sensitization to workplace allergens was registered only among bakers and it was significantly associated with atopy. The inhalable flour dust concentrations outside the workplace are not sufficient to induce allergic sensitization due to known dose-response relationship between allergen exposure and allergic sensitization [5, 25]. On the other hand, there is an evidence that atopy is associated with increase risk for IgE-mediated sensitization to high molecular weight workplace agents [26, 27].

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 [28]. Similar findings are obtained in our previous studies on workers exposed to various types of organic dust [22, 29, 30].

We found non-significantly higher prevalence of BHR in bakers that is complementary with findings of Ould-Kadi et al. [31] in a study assessing BHR by histamine challenge among industrial workers exposed to different classes of workplace agents. On the other side, BHR severity in hyperreactive subjects was significantly higher in bakers. 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. Studying male farming students, Omland et al. [32] reported additional effect of exposure to farming and daily smoking in BHR development. In contrast, Zock et al. [33] reported a non-significant association in young adults of both sexes with workplace exposure to dust, vapors, gases or fumes in 14 industrialized countries.

The present study had some limitations. First, relatively small number of the subjects in the study groups could have certain implications on the data obtained and its interpretation. Second, environmental measurements were not performed, so we could not document the effect of the level of occupational exposure on examined variables. The strength of the study is the extensive examination of respiratory health of the study subjects.

In conclusion, in a cross-sectional study aimed at assessment of adverse respiratory effects and immunological changes due to workplace exposure in industrial bakery we found higher prevalence of nasal symptoms in the last 12 months with significant difference for runny nose, higher prevalence of respiratory symptoms in the last 12 months with significant difference for cough and phlegm, lower mean spirometric parameters with significant difference for MEF_{50} and MEF_{75}, and non-significantly higher BHR prevalence with significantly higher BHR severity in bakers than in office workers. Adverse respiratory effects in bakers were close related to duration of exposure. We also found high prevalence of allergic sensitization to workplace allergens in industrial bakers which was close related to atopy. Our study confirms the need of further improvement of implementation of preventive measures in order to protect respiratory health in workers in bakery sector.

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