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ORIGINAL ARTICLE

Lung function measurements in traditional bakers

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Abstract. *Background:* Respiratory disease is common and amenable to early detection and management in the primary care setting. Spirometric and phlethysmographic evaluation of ventilatory function plays a critical role in the diagnosis, differentiation and management of respiratory illness such as asthma, chronic obstructive pulmonary disease and restrictive disorders. *Methods:* Study subjects consisted of 58 workers in the production of bread and 45 salesclerks of bread from the same bakeries. The lung function of employees was checked using a spirometry and body phlethysmography, calculating the indexes Forced expiratory volume 1 sec (FEV1), forced vital capacity (FVC), FEV1/FVC ratio, residual volume (RV), total lung capacity (TLC), and RV/TLC ratio. The percentage of the obstructive and the restrictive impairment both in the bread producers and sellers was also searched as well as the percentage of response in the bronchodilation. *Results:* Bread producers recorded significantly lower mean lung functions compared with salesclerks, for FEV1, FVC and FEV1/FVC ratio, when observed values were expressed as percentages of predicted normal values. Furthermore the percentage of obstructive impairment among the bread producers was 12, 6%, while a percentage of 20, 68% of them presented a response in bronchodilation (while the percentage in salesclerks was 6, 6% respectively). The percentage of restrictive impairment was similar in both groups (12, 6% for bread producers and 11, 1% for salesclerks). *Conclusion:* The study concluded that bread producers in traditional bakeries in Greece are at increased risk of developing airway obstruction compared with salesclerks of bread from the same bakeries. A different degree of smoking status and of wheat flour dust exposure may explain this difference. Technical preventive measures such as well ventilated work areas and appropriate respiratory protective devices should be adopted. (www.actabiomedica.it)

Key words: Bakers, lung function, spirometry

Introduction

Pulmonary functions tests are performed in order to diagnose and classify disease processes that impair lung function (1).

Lung diseases are broadly classified as those leading to airflow obstruction, volume restriction, or a combination of obstructive and restrictive defects (2).

Typically, airflow obstruction may be diagnosed using spirometry alone by demonstrating a lower than predicted FEV1/ FVC ratio (as occurs in chronic obstructive pulmonary disease (COPD) and emphysema) (3). However, spirometry is less accurate in predicting pulmonary restriction (as occurs in interstitial lung disease, respiratory muscle weakness, and thoracic cage deformities such as kyphoscoliosis) (4). A low FVC observed on spirometry can result from the restrictive pulmonary disease, or from airflow obstruction as a consequence of airway closure resulting in gas trapping rather than as a result of small lung (5-6).

When spirometry suggests a restrictive disorder, patients are usually referred for additional pulmonary function tests to confirm the diagnosis. Diagnosis of restrictive impairment depends on detecting a reduced total lung capacity (TLC), through lung volume measurements (7). Lung volumes can be measured using

plethysmography (body box), helium dilution methods or nitrogen washout method (8).

In the literature a few studies investigate the values of pulmonary function in bakers and the reversibility after the administration of a bronchodilator: only four of these studies investigate airflow obstruction, and none of these volume restrictions in bakers. (9-12)

The aim of this study was to measure the values of FEV1, FVC, FEV1/ FVC ratio, TLC, RV, and RV/ TLC ratio, and to diagnose obstructive and restrictive impairment with the use of spirometry and body plethysmography in Greek bakers, in comparison with a reference population.

Material and methods

Study design

The current study was designed as a cross- sectional study among workers from small traditional bakeries in the provinces of Patras, in south- west of Greece. All workers involved in the baking process and selling bread process were eligible for participation in the study. The population under study consisted of 58 workers exclusively involved in the production of bread and 45 salesclerks of bread from the same bakeries. The participation rate of the approached bakers was 33.2%.

Responders with a previous history of chronic respiratory problems (such as bronchial asthma, chronic bronchitis/emphysema, clinical abnormalities of the vertebral column or of the thoracic cage, or neuromuscular disease) prior to their present employment were excluded from participation in the study. All workers were white Caucasians, who lived in the same area of the city. Both groups were active subjects with similar physical workload. The study was approved by the Patras Hospital Research Ethics Board and written informed consent was obtained from each patient. Data collection was carried out between July 2003 and May 2007. The main reason for the long time to recruit subjects and the small participation of them was the concern on interference with the production routine.

Questionnaire

Data on respiratory and allergy related symptoms were collected by means of a validated respiratory questionnaire (13) administered by an occupational physician, supplemented with questions on acute work related symptoms (cough, rhinitis, dyspnoea, conjunctivitis, and sneezing) and on demographic and occupational characteristics. Questions on smoking history were based upon the ERCS questionnaire (14).

Acute work –related respiratory symptoms defined during or shortly after contact with work- related substances (such as dust flour) which improved on days off from work or on holidays (the prevalence of work related respiratory symptoms will be analyzed in another study). Smoking status was categorized as non smokers and current smokers. Current smokers were defined as those who smoked at least one cigarette daily or one cigar weekly for a period of 1 year and who were still smoking within 1 month before the examination. All other subjects were considered as non smokers. Ex smokers were excluded from the study because of small number of them (n=2). We also used the definition of packs /years, which was calculated multiplying the packs of cigarettes by the years of smoking for each person.

Spirometry and body plethysmography

Spirometric and plethysmographic testing was performed by an experienced pulmonary physician according to the American Thoracic Society guidelines (15). A maximum forced exhalation was carried out for a minimum of 6 sec., while the subjects were in a sitting position. Testing was repeated until a minimum of three acceptable flow volume loops with a FEV1 and FVC within 5% were obtained. Plethysmograph techniques were similarly performed according to published guidelines (16). For plethysmography, a minimum of two attempts with a reproducible FRC within 5% were made for each patient. We also quantified the degree of reversibility by measuring FEV1 and FVC in two steps: at baseline and again 15 min after inhalation of 400 mg salbutamol spray (Aerolin; GlaxoWelcome SA) administered with the help of a spacer (Aerochamber;Trudell Medical Inter-

national; London, ON, Canada). Spirometry testing was carried out in a different day from plethysmographic testing because of intense workload and lack of time of subjects.

Spirometric lung volume measurements were performed using a Morgan Flexiflo RS23C Interface spirometer (P.K. Morgan, UK) and plethysmographic lung volumes were performed using a MasterScreen of Jaeger body plethysmography.

All machines were calibrated with a 3-L volumetric syringe daily. Age was calculated to the nearest 6 months from birth certificates. Standing height was measured to 0.1 cm with a portable stadiometer and body weight to 0.1 kgr with portable field survey scales.

Measurements of FEV1, FVC, FEV1/ FVC ratio, TLC, RV, and RV/ TLC ratio were expressed as a percentage of predicted values in order to control the influence of age, gender, and height. We used published predicted equations taken from healthy, non smoking, and white patients. Spirometric reference values were taken from the study of Brandli et al, 1996 (17), and lung volume reference values from the study of Matthys et al, 1995 (18) based on the opinion of Baur et al, 1999 (19).Test values for the FVC, FEV1, FEV1/ FVC ratio, TLC, RV that fell below the lower limit of 95% confidence interval (CI) of the predicted values were classified as abnormal.

Spirometry and plethysmography data were categorized as being consistent with a normal pattern (normal FVC, FEV1/FVC ratio and TLC), an obstructive pattern (reduced FEV1/ FVC ratio, below LLN, with normal FVC, TLC) (4), and a restrictive pattern (defined as a reduced TLC below the lower limit of 95% (CI), (7) especially in subjects with FVC≤85% of predicted value and FEV1/ FVC ratio ≤55% of predicted value) (1). The criteria used to define a significant bronchodilator response were judged against American Thoracic Society (ATS) quidelines (≤12% of baseline and an absolute change of ≥ 200 ml in FEV1 (7).Nonwhites and patients with technically inadequate tests (due to poor patient effort or inability to perform spirometry or plethysmography) were excluded from the study. Bronchodilator and steroid treatment were stopped 24 h before the tests (n=1). The subjects were outpatients and the tests began at 09.00 a.m.

Statistics

Statistical analysis was carried out with a statistical software package" SPSS", version 10.0 and included calculation of the proportion and of the percentages, distribution control for scale variables, calculation and comparison of means (t- test with confidence interval 95% for variables with normal distribution and Mann- Whitney U –test for variables without normal distribution). Application of Pearson's correlation method (chi- square analysis) was the statistical tool of our study in order to evaluate the relationships between nominal variables. P-values lower than 0,05 were considered as significant and p-values smaller than 0, 01, as very significant.

Results

Table 1 shows the anthropometric characteristics of the two groups. As it can be observed, the mean age of bakers (p=0.02), weight and height (p=0.038, and p=0.013) were significantly greater than salesclerks' respective mean values. They worked for more years in the same occupation (p< 0.01), and showed a significant difference in their daily working hours (p=0.042).

With reference to the smoking habits, there is no statistical difference among the percentage of subjects that smoke in the two groups (84.79% in bakers versus 75.6% in salesclerks) (p > 0.05). If the number of packs/ years is taken into account then we will see that the bakers smoke a greater number of packs in comparison with the group of salesclerks (25.29 v 8.47 packs/ years, p< 0.01).

Table 2 shows the values of respiratory function that were found in spirometry and plethysmography. As it can be observed in table 2, the values of respiratory function that were found in spirometry, were significantly higher in the salesclerks when compared to the values found for the employees in bread production using the same method (FEV1, FVC, FEV1/ FVC ratio) (p< 0.01, p=0.039, p=0.002, respectively). Also, if we examine the bronchodilation response in the 2 groups, the alteration of FEV1 and FVC for the bakers is 5.91% and 6.59 % respectively, which is sta-

Table 1. Population characteristics of bread producers and salesclerks, in Numbers (%)

Characteristics	Bread producers	Salesclerks	p value (difference comparison of means)
Number of subjects	58	45	
Mean age in years (SD)	43 (12.5)	37.71 (9.48)	*
Height (cm)(SD)	172.66 (8.0)	168.38 (9.05)	*
Weight (kgr)(SD)	78.76 (15.71)	72.42(14.36)	*
Gender			
Male (%)	48 (82.75)	14 (31.1)	*
Female (%)	10 (17.26)	31 (68.9)	*
Mean number of years employed (SD)	20.57 (11.55)	11.38 (7.95)	**
Mean number of hours per day employed (SD)	9.86(2.44)	9.00(2.1)	*
Smoking status			
Never (%)	9 (15.51)	11(24.4)	p> 0.05
Current (%)	49 (84.49)	34(75.6)	p>0.05
Packs/years	25.29 (28.25)	8.47(8.56)	**

* p<0.05
** P< 0.01

Table 2. Spirometry and plethysmography parameters among bread makers and salesclerks, as means of % predicted

Lung function	Bread makers	Salesclerks	p value
FEV1 (%pred)(SD)	91.62(16.03)	101.69(10.79)	**
FVC (%pred)(SD)	94.53(14.27)	99.93(11.10)	*
FEV1/ FVC (% pred)(SD)	96.78(8.40)	101.69(6.42)	**
TLC(%pred)(SD)	104.57(24.82)	102.42(15.02)	0.61
RV(%pred)(SD)	131.09(68.75)	102.76(27.82)	*
RV/ TLC(%pred)(SD)	118.38(32.98)	101.31(18.54)	**
Mean value of reversibility of FEV1 (%pred)	+ 5.91	+ 3.67	*
Mean value of reversibility of FVC (% pred)	+6.59	+ 3.80	**

* P< 0.05
** P< 0.01

tistically higher than in the salesclerks (3.67% and 3.80% respectively),although the difference was within the normal variability.

Considering the respiratory function values shown from the plethysmography, bakers present statistically higher values for RV and RV/ TLC ratio (p=0.011, p=0.002 respectively) than salesclerks, with no statistical difference for the TLC value (p=0.61).

Table 3 shows the number of employees in both sub- groups with probable obstructive and restrictive impairment, diagnosed from the results of the respiratory trials (spirometry and body plethysmography).

Based on table 3 the employees in bread production show a greater percentage in bronchodilation response for FEV1 and/ or FVC (20.68% v 6.6%) (p<0.05). In addition, the employees in bread production show a higher percentage in the FEV1/ FVC ratio < LLN (percentage around 12.06%), while none of the salesclerks show something similar.

Finally the two groups that were examined in our study showed no significant difference in the percentage of restrictive impairment (12.06% v 11.1%).

Discussion

The large number of bakeries in Greece is traditional with regards to the division of labor and industrialization. Usually 3 to 5 people work in such units: 2 of them work in the bread production (flour mixing, making dough, baking bread) while the rest of the employees, most of them women, are salesclerks. The

Table 3. Numbers and percentages with possible obstructive or restrictive impairment in the two study groups, based on spirometric and plethysmographic lung values

Characteristics of lung volumes	Bakers (%)	Salesclerks (%)	p value (comparison of percentages)
Reversibility of FEV1 and /or FVC ≥12% (indicative reversible obstructive disease)	12 (20.68%)	3 (6.6%)	*
FEV1/ FVC ratio ≤LLN (indicative obstruction)	7 (12.06%)	0 (0.0%)	**
FVC ≤85% and FEV1/ FVC ratio ≤55% (indicative restrictive disease)	17 (29.31%)	5 (11.1%)	**
TLC≤LLN (restriction)	7 (12.06%)	5(11.1%)	> 0.05

* p<0.05
** p<0.01

salesclerks work in the same place but in different areas and working hours. Bread making takes place during the night (03.00 to 08.00) while selling takes place during daytime (08.30-15.00), in order to minimize the contact with dust of wheat flour.

The mean values of FEV1, FVC and FEV1/ FVC ratio in average vary among the different studies in bakers carried out around the world during the last decades. The findings of some of them agree with our results (9, 20-21) but others disagree (22, 23).The differences may be due to the different characteristics of the groups examined in each study, such as age, sex, race, years of work, weight, height, smoking habits and socioeconomic status.

However, the greater number of these studies showed that the employees in bread production have lower values on average of FEV1, FVC and FEV1 /FVC ratio when compared to the different control groups. Something similar was found in our study: the employees in bread production have significantly lower respiratory function values on average in comparison with the group of salesclerks (9-11, 19, 21-24).

The ATS suggest that the most important host factors responsible for interindividual variation in lung function are sex, size (measuring as standing height), aging, race, past and present health and environmental factors such as exposure to tobacco smoke (7). We related age, height, weight, sex, and smoking status (packs/ years) with the values of FEV1, FVC, and FEV1/FVC ratio among the bread bakers and salesclerks, a correlation was found only for FEV1 to height (p=0.043) packs/ years (p=0.047) and working years (p=0.027), and for FVC to height (p=0.016) (table 4-5) in the bakers. Regarding the values of RV, TLC, and RV/ TLC ratio there are no relative reports in the international literature regarding workers in bakeries in order to compare them with our findings.

However, among the two groups of our study the bread makers showed higher values for RV and RV/ TLC ratio than the salesclerks: these findings agree with the data that bread makers show high prevalence of obstruction (25)

Twenty and 68% of the bread producers showed a response to bronchodilation of FEV1 and FVC that was more than 12% (indicator of reversible airway obstruction based on American Thoracic Society) (7), which is very different from the study of Yach et al, 1985(24), which showed a percentage of 7%. This difference may be due to the fact that the study of Yach et al used 15% and not the 12% that was used in our study, as limit of response of the bronchodilation.

The employees in the study of Yach et al were working for 7.1 years on average (against 20.57 years in our study). Thus this difference may be due to ei-

Table 4. Correlation between FEV1, FVC, ratio FEV/FVC, and TLC with age, sex, weight, height, working years, working hours, smoking status, packs/ years in bread makers (N=58)

	FEV1 p value	FVC p value	FEV1/ FVC p value	TLC p value
Age	,071	,379	,077	,146
Sex	,575	,510	,846	,416
Weight	,631	,218	,143	,572
Height	,043*	,016*	,500	,067
Working years	,027*	,249	,053	,114
Working hours	,971	,651	,270	,290
Smoking status	,055	,169	,375	,993
Packs/years	,047*	,341	,103	,068

* Correlation is significant at the 0.05 level
** Correlation is significant at the 0.01 level

Table 5. Correlation between FEV1, FVC, FEV1/ FVC ratio, and TLC with age, sex, weight, height, working years, working hours, smoking status and packs/ years in salesclerks (N=45)

	FEV1 p value	FVC p value	FEV1/ FVC p value	TLC p value
Age	,698	,583	,227	,308
Sex	,800	,911	,316	,597
Weight	,619	,594	,098	,553
Height	,894	,813	,131	,994
Working years	,511	,177	,876	,487
Working hours	,304	,249	,567	,275
Smoking status	,529	,449	,791	,709
Packs/ years	,732	,992	,747	,644

* Correlation is significant at the 0.05 level
** Correlation is significant at the 0.01 level

ther the different definition of response or to the greater number of years of exposure to flour (probable sensitization) or to both factors.

Based on the initial definition that employees with a FEV1/FVC ratio ≤LLN had obstruction, it was found that in the group of bread producers the number was 7 (12.06%) against none in the group of salesclerks. This percentage agrees with the results of the study of Baur et al, 1998(11), in which the percentage was 17%. The study of Shammsain et al, 1995 (9) examined African male bread bakers and used the FEV1/ FVC ratio ≤70% of predicted value as an indicator, finding obstruction in 37%, which was much greater than in our study. This may be due to differences in race, sex, weight and different exposure to flour. These results agree with the percentage of obstruction show in the study of Pavlovic et al 2001 (12), which found that 12% of bakers had airway obstruction and with the study of Musk et al 1989 (10), in which the percentage of bakers with obstructive disease was 14%.

Restrictive impairment in bakers is not analyzed in any study in the international literature. This is reasonable since in bakeries around the world, the most common occupational disease is asthma, an obstructive disease, whose diagnosis requires easy and inexpensive spirometry. On the contrary, for the diagnosis of restrictive disease, spirometry is not accurate and therefore plethysmography is used (26).

In our study no difference regarding restrictive disease was shown in the two study groups (12.06% v 11.01%). This was expected because if the two groups are compared based on the BMI index no significant difference is shown (p=0.65). Moreover the TLC values were examined in both groups for sex, smoking status, packs/ years, height, weight, age, working years and working hours and no correlation was found (4-5).The results in our study correspond with the results of Aaron et al, 1999 (4) (percentage of restriction 12.3%) where 1831 white adults were studied without considering their occupation. In a study in Nigeria (27), the authors found that 8% of flour mill workers had restrictive impairment, but only spirometry without body plethysmography was used for diagnosis.

We also confirmed the fact that a positive predictive spirometric value of restriction shows a lower (54.5%) percentage which agrees with the study of Aaron et al 1999(4), where the percentage was 58%.

However, in our study there may be some inaccuracies that must be underlined. As previously mentioned the two groups showed great differences in the average of packs/ years, age, sex, working years, height, and weight, all factors that can affect the FEV1/ FVC ratio and may represent cause for the obstruction in bakers, either alone or in combination. The study between FEV1 / FVC ratio and age, sex, height, weight, working years, smoking status, packs/years, working hours found no correlation in the two groups, but is not sufficient to exclude the artifact, by itself.

In order to verify the effect of wheat flour dust on lung volumes of bakers, further studies, including greater number of employees with similar smoking habit and providing dust levels in traditional bakeries in Greece, are required.

The present study confirms the findings that workers with wheat flour have an obstructive pattern of lung function impairment. The findings are of importance in that they demonstrate the extensive need for preventive measures. It is advisable therefore that baker manager, the workers and health officials should work together to adopt technical preventive measures, such as having well ventilated work areas and wearing appropriate respiratory protective devices. It is also suggested that bakers must undergo pre-employment and periodic medical surveillance tests.

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