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Asthma and rhinitis in Greek furniture workers

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ABSTRACT

Objective: The detection of asthma and rhinitis in furniture workers exposed to chemicals in the area of Thessaloniki Greece and the determination of the most useful tests for diagnosing the above occupational diseases.

Methods: Eighty-three workers (76 men), 35 exposed to chemicals (CW), 23 to wood dust (WW), and 25 office workers (OW), serving as controls, filled in a specialized European Community Respiratory Health Survey (ECRHS) questionnaire for asthma and were submitted to clinical evaluation, spirometry, bronchodilation test, PEF computer algorithm OASYS-2, FeNO, skin prick tests (SPTs), rhinomanometry and methacholine inhalation challenge. Working conditions and protective measurements were also recorded. According to the results of all conducted tests, each subject was distributed to a subgroup: (a) normal, (b) asthma, (c) rhinitis, (d) asthma and rhinitis. Comparisons were performed among work groups. **Results:** The presence of asthma and/or rhinitis was higher among CW and WW compared to OW ($p = 0.004$). Significant differences among groups were observed in the questions «better weekend» ($p < 0.034$) and «improvement on vacation» ($p < 0.000$), in OASYS-2 Score ($p < 0.000$), in ABC Score ($p < 0.000$), and in methacholine score ($p < 0.022$). Rhinomanometry, FeNO, spirometry, and spirometry after bronchodilation had no significant differences among groups. Working conditions, ventilation system, work practice, use and type of mask revealed no significant differences.

Conclusion: Asthma and rhinitis are significantly common among CW. Protective measurements used were not adequate to prevent asthma and or work related rhinitis. Early diagnosis might contribute to disease prevention and control.

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Introduction

Work-related asthma (WRA) and work-related rhinitis (WRR) are medical conditions characterized by variable airflow obstruction and/or bronchial hyperresponsiveness and associated with airway inflammation due to one or more substances and/or conditions encountered in the work environment, and not outside it (1–4).

WRA is often underdiagnosed (5). However, 5–25% of new cases of adult onset asthma can be attributed to the workplace (5–7). In the furniture industry, many different tasks are prone to wood dust exposure and several hazardous chemicals are used in paints, polishes, and lacquers either as solvents or as stabilizers of paint (e.g. acid N-butyl ester, acid ethyl ester, 2-butanone, toluene, xylene, ethyl ethoxy propyl ester, 2,4/2,6-toluene diisocyanate, formaldehyde, hexane, methylene chloride). Particleboard and fiberboard recently used more frequently are wood products containing adhesives and

resins (8,9), but according to the European Union standards regarding implicated health hazards they are considered as natural wood (10,11). Therefore, the furniture industry is considered as a high-risk work environment for the development of WRA and WRR. Various studies have mainly examined the health effects of one agent, either toluene diisocyanate or formaldehyde (12,13). But workers in furniture processing could have an increased risk of developing WRA due to many other implicated substances.

Most workers are referred to the clinician after they develop symptoms impeding them to work or to everyday activities. Thus the economic burden of the disease might be extremely high due to late diagnosis (7). The socio-economic cost of having to change occupation after a diagnosis of WRA is also very high (14). The official diagnosis of WRA and rhinitis is quite difficult and includes a stepwise approach (3,4).

Furthermore, it is necessary to determine the basic diagnostic laboratory tests that should be routinely determined to all employees (15). Improving working conditions could possibly reduce the risk of developing asthmatic symptoms and bronchial hyper-responsiveness (16).

Published data on WRA in Greece are very scarce (17). The aim of this study was to detect the frequencies of WRA and rhinitis in the area of Thessaloniki Greece, in a sample of furniture workers and also to investigate the impact of different tests and airway inflammation markers on the establishment of WRA and rhinitis diagnosis.

Methods

Study design

We reached out to the Greek Statistical Authority (HELSTAT) to get a complete list of furniture factories in the Thessaloniki Prefecture (18). Our research revealed 162 active furniture companies with a total of 1522 workers.

Study population and exposure groups

The study population consisted of workers in the wood furniture manufacturing sector. Approval was obtained by the Bioethics Committee of the Aristotle University of Thessaloniki. All employees volunteered to participate in the study. The initial cross-sectional study was conducted between 2011 and 2012 in the wider Thessaloniki Prefecture, Greece. A random sampling was conducted based on enterprise size and working positions. In this way, approximately 105 volunteer employees were initially selected, 98 men and seven women. Twenty-two men were excluded because they did not complete all study tests. Eventually, 83 of the initially selected employees, 76 men, were fully evaluated in this study.

Employees were divided into three groups based on their occupational exposure to (a) wood dust, (b) chemicals, and (c) office employees (control group). G Power (3.0.10) was used to calculate the optimal sample size. For an effect size $f=0.5$ and an error prob = 0.05 for three groups the total sample size had to be more than 63 (our study sample was 83).

- a. Wood group. This group consisted of 23 employees who worked exclusively in the wood processing sector (cutting, polishing) and were exposed to wood dust. The types of wood they exposed to were mainly particleboard (MDF) and fiberboard

(NOVOPAN), which are considered to have dust profiles very similar to natural wood (11), and infrequently pine, beech, and oak.

- b. Chemical group. This group consisted of 35 employees who worked in the furniture painting and mounting sector, using glue and paint. We took information from safety data sheets of the materials in order to record the chemicals contained in lacquers, varnishes, and adhesives. These included: toluene isocyanate, 2,4/2,6 toluene diisocyanate, formaldehyde, xylene, acid butyl ester, acid ethyl ester, phthalate butyl ester of benzene, propylene glycol, acetone, and various acrylic resins (polymethyl-methacrylate-PMMA, polyvinyl acetate-PVA, etc.).
- c. Control group. This group consisted of 25 subjects working in the offices and not exposed to wood dust or chemicals in the last 2 years.

The study population consisted strictly of morning shift employees (from 7 to 8 a.m. to 3 to 4 p.m.), on a 5-day work week basis, weekends excluded. Individuals with previously diagnosed medical conditions (e.g. asthma, bronchiectasis, chronic obstructive pulmonary disease, any other pulmonary disease, arterial hypertension, cardiovascular diseases were excluded). Employees willing to participate but working in the afternoon or night shift were excluded.

Examination tests

The study was accomplished in three separate time-point visits.

During the first visit, the workplace was explored and the working conditions such as ventilation systems, personal protective equipment (PPE), types of wood were recorded. Information from safety data sheets of all chemical substances in use was also recorded.

During the second visit, the following tests were performed:

1. Questionnaire.

Personal data were collected according to the instructions by the European Community Respiratory Health Survey (ECRHS) for asthma (6). The questionnaire included questions about symptoms such as wheezing, chest tightness, shortness of breath, dyspnea, cough, and nasal symptoms. That is nasal congestion, sneezing, rhinorrhea, and itching (6,15). Questions about living conditions and medical history

were also included. The symptomatic subjects were asked to specify if the onset of their symptoms occurred after initiation of this job and at which time point approximately. Moreover, improvement of symptoms during the weekend and/or during holidays was also recorded (6,19). The questionnaire also included questions about ventilation system, work practice as well as use and type of protection masks (simple mask/or mask with filter) (16).

2. Clinical examination was performed.
3. Spirometry pre and post bronchodilation

Spirometry was performed in the middle of the shift (11–12 am) by a Spirobank G portable device, (MIR-Medical International Research Company Rome, Italy), connected to a computer according to ATS guidelines and global lung function predicted values (20,21). Post bronchodilation spirometry was performed 20 min after administration of 400 mcg salbutamol. Improvement in FEV₁ more than 12% and >200ml after bronchodilation was considered diagnostic for asthma according to the Global Initiative for Asthma Guidelines (GINA) (22).

4. Measurement of Peak Expiratory Flow Rate (PEFR)

A portable mini Wright peak flow meter (Standard Range scale, EU, EN 23747) was given to every employee. They were asked to record the maximum value of three attempts of forced expiratory flow. According to the instructions, employees had to record one measurement in the morning at the beginning of their shift (7–8 a.m.), another one in the middle of it (12 a.m.), just before stopping (3–4 p.m.), and the last one before bedtime (11 p.m.). The same measurements were recorded during the weekend and for two weeks during vacation (1). We recorded measurements of peak flow by workers using the computer algorithm “Occupational Asthma System (OASYS-2)” (23), which is a computer program that uses discriminant analysis in order to calculate a score between 1 and 4, indicating the likelihood of a specific PEF recording to be compatible with the diagnosis of WRA (23,24). An OASYS-2 cut off score of 2.5 was used in this analysis. In addition to the above system, the area between curves Score (ABC Score) with a cut off point of 10 l/min/h was used as a diagnostic criterion (25).

During the third visit, which was always on a working day, employees visited the Bronchial Asthma Out-patient Clinic of the Pulmonary Department

Aristotle University of Thessaloniki (AUTH). The following tests were performed during the third visit:

1. Fractional exhaled nitric oxide (FeNO)

FeNO was measured at an expiratory flow rate of 50 ml/s by a chemiluminescence analyzer (CLD 88sp; ECO MEDICS AG, Duernten, Switzerland) according to the latest American Thoracic Society/European Respiratory Society (ATS/ERS) recommendations (26). Repeated exhalations were performed to obtain at least three FeNO plateau values within 10% of each other. The final result was the average of three threshold values, i.e. variation of measurements less than 10% (26).

2. Skin prick tests

Skin prick tests (SPTs) were performed by the modified prick method (modified SPT) with allergen extracts including histamine as a positive control and diluent as a negative control (27). The allergens tested were house dust mites (*D. pteronyssinus*, *D. farinae*), animal dander, grass pollens, tree pollens, and molds (Allegopharma, Germany). The largest wheal diameter was measured 15 min after the test. The result was considered positive if the diameter of the wheal was at least 3 mm, compared to the negative control (28).

3. Rhinomanometry

Anterior active rhinomanometry was used to measure nasal flow (29) with rhinomanometer Rhinotest 2000 plus (EVG Electronic Vertriebs GmbH, Bohl-Iggelheim, Germany). Each subject was breathing quietly in the sitting position via an air-tied face mask with one nostril open and an intranasal sponge with a catheter—probe into the other nostril for transferring the pressure variations to the device. This probe, positioned to the nasal chamber, captures the airflow using a pneumotachograph. In the computer screen, real time, linear graph of pressure, and flow is done and nasal flow chart displayed (vertical axis, cm³/s) versus the pressure difference between the inlet of the free nostril and the pressure recorder located in the nasal funnel of the closed nostril (horizontal axis, Pa). The resistance of each nasal chamber was calculated from the pressure difference quotient to flow, under the assumption that the air flow was linear. Flow was measured at a transnasal pressure of 150 Pa and reported as nasal flow sum (adding flow for both nostrils) in cm³/s increased resistance indicated rhinitis (29).

4. Methacholine challenge test

Methacholine was administered by a controlled tidal volume breathing dosimeter technique using the Aerosol Provocation System with a Medic-Aid nebulizer (Jaeger GmbH and Co KG, Wurzburg, Germany), with technical characteristics calibrated at 7 l/min Flow and 0.9 bar Pressure, mean diameter 3.2 μ m, nebulizer performance: 160 mg/min (30). Initially, the examined person inhaled a saline solution (NaCl) and the maximum value of FEV₁ was recorded by spirometry. This value was designated as the reference value. The next step was administration of a dilution 1% methacholine in saline, in doubling cumulated doses starting from 0.06 mg. Two minutes after each provocation step FEV₁ was measured. If the provocation dose (PD) was not yet exceeded, the program automatically started the next provocation step. The test continued until a positive response occurred, that is 20% fall in FEV₁ compared to its initial inhalation value or when the final dose of 2.5 mg cumulated methacholine was reached. The system calculated the PD automatically (30,31). Patients diagnosed with asthma presented a reduction in FEV₁ greater or equal to 20%. Airway hyperresponsiveness was defined as a provocative dose of methacholine of 2.5 mg or less required to cause a 20% fall in FEV₁ (31).

Statistical analysis

Data were analyzed using the statistical software SPSS (statistical program for social science) version 21.0 (SPSS IBM Inc., Chicago, IL). Comparisons among groups were analyzed using one-way ANOVA in SPSS Statistics followed by *Post hoc* Bonferroni tests and the Kruskal–Wallis H, as a rank based nonparametric test. Data were reported with the summary statistics of the variables including their mean values, standard deviation values and their confidence intervals (for 95% confidence level). Normality of distribution of the variables was also checked. A p values < 0.05 was considered significant to reject the null hypothesis of normal distribution. A normal distribution of our data was hypothesized using the Shapiro–Wilk test of normality. We preferred this test instead of Kolmogorov–Smirnov one sample test because in each parameter the number of cases was less than 50.

We also conducted chi-square tests to summarize the significant differences among several categorical variables. Stratifying by working position comparison was performed among three groups of employees: wood group, chemical group, and control group.

Workers were also classified into the following disease subgroups according to GINA instructions (22). Each worker classified belonged to only one group:

- normal (all tests were negative),
- asthma (lung symptoms, positive methacholine challenge test $\pm$ bronchodilation test),
- rhinitis (nasal symptoms and nasal obstruction in rhinomanometry) and
- asthma and rhinitis (lung and nasal symptoms positive methacholine test and nasal obstruction in rhinomanometry).

Moreover, contingency tables were used to summarize relationships among work groups and FeNO, methacholine challenge test, OASYS-2 Score, and ABC Score. Chi Square test was used to find the relationship between two nominal variables for significance and the non-parametric method, Kruskal–Wallis test, to find significant differences among more than two groups.

We also conducted *t*-test and chi-square tests between the following two groups of workers:

- chemical and wood particle exposure group as a whole, consisted of furniture workers using both chemicals and wood
- the control group, consisted of office workers (OWs)

Results

A total of 83 workers, 76 men, 7 women, were included in this study. The demographic characteristics as well as data about respiratory symptoms and spirometric parameters are shown in Table 1. There were no statistically significant differences regarding respiratory and nasal symptoms among groups. Comparison among groups displayed statistically significant difference in the questions: “improvement during holidays” and “improvement during the weekends”. Both questions favored positive answer in the chemical exposure group (Table 1) (one-way ANOVA).

The frequency of nasal symptoms in the disease subgroup “asthma” was 54.5%. In the disease subgroup “asthma and rhinitis” all workers had nasal symptoms. The most frequent symptom nasal congestion was 45.5% in the subgroup “asthma” and 66.7% in the subgroup “asthma and rhinitis” (Kruskal–Wallis tests, frequencies split files layered by disease subgroups).

Results of more specific tests that were performed during the visit of workers in the Pulmonary

Table 1. Main characteristics of the examined population stratified by exposure group.

Characteristics <i>n</i>	Control group 25	Chemical group 35	Wood group 23	<i>p</i> *
Age ^a years mean $\pm$ SD	44.00 $\pm$ 7.56	42.74 $\pm$ 9.27	44.61 $\pm$ 9.07	0.708
Gender (male)	18	35	23	—
Length of employment ^a years, mean $\pm$ SD	17.68 $\pm$ 7.78	20.54 $\pm$ 11.7	19.452 $\pm$ 10.63	0.575
Smoking habit Pack/years ^a mean $\pm$ SD	23.43 $\pm$ 21.7	10.69 $\pm$ 15.46	21.96 $\pm$ 25.17	0.034*
Non smokers % (frequency)	44.0	45.7	47.8	—
Ex smokers % (frequency)	16.0	11.4	13.0	—
Smokers % (frequency)	40.0	42.9	39.1	—
Chronic cough ^b	43.30	43.30	38.61	0.473
Wheezing ^b	41.80	41.80	42.52	0.985
Chest tightness ^b	43.14	38.87	45.52	0.193
Dyspnoea ^b	43.32	40.00	43.61	0.219
Nasal symptoms ^b	40.92	43.53	40.85	0.850
Symptoms after the end of a work shift ^b	32.14	50.40	39.93	0.003*
Improvement in weekend ^b	35.32	47.41	41.02	0.034*
Improvement in vacation ^b	27.64	50.64	44.46	0.000*
FEV ₁ % mean $\pm$ SD	99.48 $\pm$ 13.41	97.88 $\pm$ 16.04	97.0 $\pm$ 17.85	0.862
FVC % mean $\pm$ SD	98.56 $\pm$ 14.98	95.6 $\pm$ 16.31	94.74 $\pm$ 20.56	0.719
FEV ₁ /FVC% mean $\pm$ SD	105.5 $\pm$ 69.19	105.68 $\pm$ 9.07	107.30 $\pm$ 11.43	0.786
PEF % mean $\pm$ SD	101.67 $\pm$ 14.33	102.57 $\pm$ 20.93	101.91 $\pm$ 19.71	0.214

^aDescriptives by one way ANOVA/ mean value.^bMean Ranks by Kruskal–Wallis test.

*Level of significance/the mean difference is significant at the 0.05 level.

Table 2. Examination tests and significance between work groups*.

Test ^a	Group	<i>n</i>	Mean rank	<i>p</i> **
Asthma/rhinitis***	Chemical	35	50.63	0.004**
	Control	25	32.94	
	Wood	23	38.72	
Bronchodilation	Chemical	35	45.37	0.087
	Control	25	37.64	
	Wood	22	39.73	
Methacholine challenge testing	Chemical	35	47.06	0.031**
	Control	25	36.28	
	Wood	22	38.59	
PEF analysis by OASYS	Chemical	31	39.08	0.001**
	Control	16	20.50	
	Wood	17	31.79	
PEF analysis by ABCURVES	Chemical	31	36.79	0.016**
	Control	16	27.50	
	Wood	17	29.38	
Fractional exhaled nitric oxide (FeNO)	Chemical	35	42.51	0.722
	Control	25	40.64	
	Wood	22	40.86	
Rhinomanometry Summary (left and right rhinomanometry/SUM)	Chemical	35	42.99	0.683
	Control	25	39.42	
	wood	22	41.5	
Questionnaire-symptoms after the end of the shift	Chemical	35	50.4	0.003**
	Control	25	32.14	
	Wood	23	39.93	
Questionnaire-improvement on weekend	Chemical	35	47.41	0.034**
	Control	25	35.32	
	Wood	23	41.02	
Questionnaire-improvement on holidays	Chemical	35	50.64	0.000**
	Control	25	27.64	
	Wood	23	44.46	

^aThe above numbers refer to positive test results.

*Mean ranks by Kruskal–Wallis test.

**The mean difference is significant at the 0.05 level.

***Comparison between disease groups and work groups.

Department are presented in Table 2. Methacholine challenge testing, PEF analysis by OASYS, and ABC score were statistically significant different while skin prick tests with common allergens, FeNO and nasal flows measured by rhinomanometry displayed no significant differences among groups (Table 2).

Asthma, rhinitis, and their combination were more frequent among chemical exposure employees. In the chemical exposure group 22.9% ($n=8$) of the workers were diagnosed with asthma, 25.7% ($n=9$) with rhinitis and 11.4% ($n=4$) with asthma and rhinitis ($p < 0.038$). In the wood exposure group, 8.7% ($n=2$)

Table 3. Examination tests and descriptive significance among work groups.

Test	Work group	n	Mean	SD	p**
Diurnal variation of PEF analysis by OASYS-2 score	Chemical	31	2.30	0.71	0.000**
	Control	16	1.44	0.48	
	Wood	17	2.09	0.53	
Diurnal variation of PEF analysis by area between curves score	Chemical	31	5.72	8.96	0.000**
	Control	16	−4.46	5.24	
	Wood	17	2.29	4.72	
Methacholine challenge test cumulative dose PD20 mg	Chemical	35	1.66	0.90	0.022**
	Control	25	2.16	0.57	
	Wood	22	2.11	0.68	
Fractional exhaled nitric oxide (FeNO)/ppb	Chemical	35	14.42	9.13	0.581
	Control	25	12.98	5.28	
	Wood	22	15.24	6.93	
Rhinomanometry summary (left and right rhinomanometry)/cm ³	Chemical	35	455.54	193.09	0.270
	Control	25	529.00	141.15	
	Wood	22	483.18	168.04	

*One-way ANOVA.

**The mean difference is significant at the 0.05 level.

exhibited asthma, 17.4% ($n=4$) rhinitis and 4.3% ($n=1$) asthma, and rhinitis. Finally, in the control group, 4% ($n=1$) were diagnosed with asthma, 8% ($n=2$) with rhinitis and 4% ($n=1$) with asthma and rhinitis.

During the first step of the survey, we recorded the working conditions as well as the PPE used by workers. We compared the disease subgroups to the presence of ventilation system, use of mask, type of mask, and work practices. The results displayed no statistically significant differences. However, in the disease subgroup asthma and rhinitis, the Mean Ranks was numerically lower compared to the other three disease subgroups (28.00 for ventilation system, 36.33 for the type of mask and 34.75 for the use of mask).

The combined use of the OASYS-2 score and ABC Score revealed significant differences among groups. Specifically, a statistically significant difference among the groups was found in the OASYS-2 score, with the control group having the lowest value ($p < 0.000$). Concerning the ABC Score statistically significant difference was observed among groups ($p < 0.000$), while the wood and the control groups exhibited lower values compared to the chemical group (Table 3).

In contrast, statistically significant difference was observed among the groups for methacholine (PD20 FEV₁) measurements, where the lowest values were found among workers employed in chemicals ($p < 0.022$) (Table 3).

Statistical analysis between the whole chemical and particle exposure group and the control group revealed significant differences in OASYS Score ($p < 0.000$), in the questions «better weekend» ($p < 0.024$), and «improvement on vacation» ($p < 0.000$). Comparison between the above two groups concerning the distribution in the «disease subgroups» revealed significant differences ($p < 0.010$), whereas in the comparison

between chemical and wood groups the differences were highly significant ($p < 0.004$). No significant differences were found in ABCURVES score ($p < 0.055$), in methacholine test ($p < 0.060$), in rhinomanometry ($p < 0.537$), and spirometry after bronchodilation test ($p < 0.098$) comparing the chemical and wood particle exposure group as a whole with the controls, whereas there were statistically significant differences for the chemical exposure group in OASYS Score ($p < 0.001$), along with ABCURVES score ($p < 0.016$), in the questions «better weekend» ($p < 0.034$) and «improvement on vacation» ($p < 0.000$), but also in the methacholine challenge test ($p < 0.035$) which is an important tool for the diagnosis/exclusion of asthma. FeNO, rhinomanometry, spirometry before, and after bronchodilation data showed no statistically significant differences among groups.

Discussion

In this study, we aimed to define the presence of WRA and WRR in a sample of furniture workers in the area of Thessaloniki, Greece and also to determine the usefulness of different tests for early screening the disease. To our knowledge, there was no other study about medical surveillance conducted in the furniture industry in Greece. We performed a complete evaluation using the ECRHS questionnaire, spirometry before and after bronchodilation, FeNo measurements, skin prick tests, rhinomanometry, and PEF records using the OASYS score and ABC score for the detection of WRA. The evaluation of this variety of tests for screening WRA has not been found in any previous published studies in the literature. Specific Inhalation Challenge (SIC) tests are not standardized, and are not used in many countries, including Greece and thus were not performed in our study (32).

In this study, we showed that asthma and/or rhinitis are much more common diseases among chemical and wood workers compared with office workers. We found that using a specific questionnaire including questions about the improvement of symptoms on holidays which is more prominent compared to the improvement of symptoms over the weekend, could reveal WRA. We validated the diagnostic value of Peak Expiratory Flow Rate measurements using the computer algorithm OASYS-2 score and ABC score even measured with suboptimal data and also the methacholine challenge test proved to be an important diagnostic procedure.

Our results are compatible with a cross-sectional epidemiological study by Mastragello et al. (12) who explored a sample of factory workers exposed to isocyanates and revealed that the risk of asthma was five times higher compared to unexposed workers. In another study, Talini et al. (33) showed that chemical workers have a greater risk of developing asthma symptoms, in contrast to Milanowski et al. (34) who demonstrated that the asthma-like symptoms were more frequent among employees in the wood department. Ucgun et al. (35) explored asthma prevalence in a region of Turkey and concluded that WRA was a common disease for furniture workers employed in the paint sector, they also suggested that smoking and atopy were significant contributors. In our study, chemical workers although exhibiting an increased frequency of asthma compared to the other two groups, did not show significant relation to smoking or to atopy.

Generally, atopy was not frequent among groups in our study. Atopy is reported to increase the risk of WRA to many high molecular weight agents but the same is not observed in low molecular weight agents (3,15). Anees et al. (36) concluded that asthma caused by low molecular weight agents can be separated into eosinophilic and non-eosinophilic pathophysiological variants with the latter predominating. Atopy in our study was not statistically significant. Concerning respiratory function, no significant differences were observed in spirometry findings before and after bronchodilation in this work. This conclusion agrees with Arbak et al. (37) who showed increased incidence of rhinitis and respiratory symptoms among furniture workers, but spirometric parameters were comparable with the controls. The same conclusion was drawn by Talini et al. (33) and Baran et al. (38) who also found no differences in lung function tests after exposure to woods dust. In contrast Jacobsen et al. (39) studied the relationship between lung function and exposure

to woods dust and observed lung function impairment mainly among women.

Regarding the value of PEF records there is a vast variety of data showing that PEF variation on weekends and vacations was superior for the diagnosis of WRA compared to cross-shift spirometric changes (1,3,4). Park et al. (40) came to the same conclusion. Burge et al. (23) developed a system for measuring PEFR in the diagnosis of WRA, the OASYS-2 Score, and Moore et al. (25) developed another diagnostic score for WRA, Area Between Curves Score. We used both of them in our study. There was a statistically significant difference in both of the above scores in relation to work position, being statistically more significant in the chemical and wood groups, compared to control group, but not statistically significant between the wood and chemical groups (*Post hoc* tests by One Way ANOVA). The above scores turned out to be an objective guide alone or in combination with methacholine measurements for the detection of WRA.

Concerning the FeNO measurements in all participating employees ($n=83$), our study statistical analysis revealed no significant differences in FeNO values among groups. Only 5 out of 83 subjects demonstrated FeNO levels above 25 ppb (three out of 11 with asthma, one out of 15 with rhinitis and one out of six with asthma and rhinitis). A possible explanation to this discrepancy in our results is probably the fact that asthma caused by low molecular weight substances has a different pathogenic pathway compared to that of allergic asthma (3,7,15). Another important issue is that we used FeNO as a screening test and not as a test in already diagnosed asthma. However, no generally accepted cut off point exists for the measurement of FeNO as a diagnostic tool for asthma though in some studies authors made an attempt to define it. Berkman et al. (41) found that a cut off point of > 7 ppb could distinguish asthmatics from non-asthmatics and that it could be used as a diagnostic test for asthma. The study by Henriksen et al. (42) used a cut off point of > 8 ppb, and showed that measurement of FeNO by itself was not such a useful tool in population surveys but only in combination with the measurement of bronchial hyperresponsiveness it constituted a specific finding for allergic asthma. In that context, in all our study groups, values of FeNO > 7 ppb were observed in 9 out of 11 employees diagnosed with asthma (7 in the chemical versus 2 in the wood group), in 10 out of 15 diagnosed with rhinitis (8 in the chemical versus 2 in the wood group) and in 3 out six with asthma and

rhinitis (2 in the chemical and 1 in the wood group), but with no significant differences compared to controls.

Concerning the confirmation of rhinitis by rhinomanometry or by nasal symptoms there was no statistically significant difference among groups. WRA and WRR frequently co-exist and our study showed that over half of workers with asthma had also nasal symptoms. Castano et al. (43) showed that WRR can be assessed by objective means and it often coexists with WRA but can be present without WRA. Karjalainen et al. (44) showed a clearly elevated risk of asthma among patients with WRR.

In our study, positive methacholine challenge testing was more prevalent and significant in the chemical exposure group. In general, methacholine challenge test is a well-established tool for identifying airway hyperresponsiveness with high sensitivity compared to spirometric parameters and bronchodilation testing (22). The absence of airway hyperresponsiveness on challenge testing has a fairly negative predictive value (22). This is crucial because diagnosis of asthma is a necessary step for diagnosis of WRA (4). Pralong et al. (45) showed that a negative methacholine challenge test in a patient still exposed to the causative agent at work makes the diagnosis of WRA very unlikely. In contrast, Walters et al. (46) believe that airway hyperresponsiveness should not be used to exclude patients with WRA symptoms from referral to specialized units and further investigation. In both, the above studies subjects had been submitted to a specific challenge test.

Regarding the impact of controlling occupational exposure on the prevention of WRA, Heederik et al. showed that exposure elimination is the strongest and preferred measure. Personal protective equipment in preventing WRA is limited (16). In our study, statistical analysis revealed no significant differences among the disease subgroups and the working conditions, as well as the PPE. This result demonstrates the importance of early asthma diagnosis.

There were some limitations of this study. The current economic crisis led to small number of participants (ELSTAT data) (18). Another important issue was poor compliance with measurement of PEFR as reliable data for the whole study population, was only available for two consecutive weeks, including days off work, instead of four (4). There was also great heterogeneity regarding work practices, ventilation systems, PPE, and their proper use that probably affected the results.

In conclusion, our study focusing on detection of asthma and rhinitis among furniture workers in the area of Thessaloniki, Greece, revealed that asthma and/or rhinitis are more common among chemical and wood workers. The most useful tools for diagnostic screening were specific questions on “improvement on holidays”, “improvement on weekends”, PEFR measurements, including days off work, with OASYS-2 Score and ABC Score as well as the methacholine challenge test. Work practices, the use of mask and the presence of a ventilation system have not shown any protective role for the prevention of asthma or rhinitis in this study.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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