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RELATIONSHIP BETWEEN CONCENTRATION OF WELDING FUMES AND CHANGES IN WELDERS' LUNG FUNCTIONS

HOSSEIN KAKOEE*, Ph.D.

From the Department of Occupational Health, School of Public Health, Tehran University of Medical Sciences, P. O. Box 6446-14155, Tehran, Islamic Republic of Iran.

ABSTRACT

In order to evaluate the relationship between the concentration of welding fumes and cigarette smoke on the bronchopulmonary system function, a comparative study of spirometric measurements in 100 welders and 50 healthy volunteers was performed in an automobile manufacturing company. Two groups of workers were matched according to their age, height, smoking habit, years of service and social class. Their health survey was evaluated by questionnaires, spirometry, chest x-ray and clinical research. Statistical tests were done for all variables of groups showing different types of pulmonary functions. 32 percent of welders had a reduction in pulmonary function, and respiratory symptoms such as dyspnea, cough, rales and sputum. Chest x-ray abnormalities (assidrosis) were higher in welders (22%) than the control group (8%).

Keywords: Occupational Health, Welding Fumes, Welder's Lung Functions.
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INTRODUCTION

Pollutants such as toxic gases and fume particles produced in the welding process (which are usually smaller than one micrometer) and tobacco smoke can gain access to the respiratory tract. Some of these particles are able to reach the terminal alveolar endings. They may be destroyed, distributed throughout the body, or remain in the lung and lymph channels and glands within the chest which drain the lung area, where they may exert a wide variety of effects. Although the resulting inflammatory changes in the respiratory tract are mild, they can lead to changes within the lung which result in respiratory symptoms and functional disturbances, i.e., inability to inspire deeply, inability to exhale (airway obstruction), and impairment of oxygen diffusion in the lung capillaries. These adverse effects on the lung can be detected by determination of the vital capacity (VC), the forced expiratory volume in one second (FEV_1), forced vital capacity (FVC) and forced mid-expiratory flow (FEF 25%-75%).

The possible harmful effects of welding fumes have been discussed for many years, especially with the increasing use of manual metal arc welding (MMA), and metal inert gas welding (MIG), which usually involves various potential respiratory hazards.[1-7] In the present investigation, relatively large groups of MMA and MIG welders and non-welder controls were compared by spirometry, lung radiography, FVC and FEV_1 before starting the morning shift in the automobile manufacturing industry located in Arak (IRI). The main objective of this study was to evaluate the correlation rate of factors such as age, height, weight, work experience, and years of smoking upon pulmonary function and to obtain regression equations for pulmonary function parameters in case and control groups.

* Assistant Professor, Depatrment of Occupational Health, School of Public Health, Tehran University of Medical Sciences, P. O. Box 6446-14155, Tehran, Islamic Republic of Iran.

Table I. Comparison of age, height, weight and duration of service among welders and controls.

Group	No. of Cases	Mean Age (yrs) (SD)	Mean Height (cm) (SD)	Mean Weight (kg) (SD)	Duration of service (yrs)
Welders	100	39.73 (5.78)	169.61 (6.66)	70.08 (10.98)	15.28 (5.91)
Controls	50	38.06 (7.18)	171.1 (7.68)	74.66 (6.85)	14.94 (6.86)

MATERIALS AND METHODS

Manual metal arc welders (MMA), and metal inert gas welders (MIG) as full-time employees were selected. To insure coverage of all possible durations of exposure, it was decided to include workers with five years or more experience. To avoid the influence of sex, only men were included in the study. The results obtained in the group of welders were compared with those of a group of non-welder controls similarly studied. The controls had been exposed to the same general environment for at least ten years, but had never been welders. Of the 300 welders and 100 controls that were initially examined, 100 welders and 50 controls fulfilled the accepted criteria. The conditions of measurements were standardized by performing the tests before starting work in the morning, to exclude daily exposure and to minimize any change attributed to diurnal variation. The respiratory symptom questionnaire was used in an interview to obtain a medical and occupational history and information on smoking habits.

RESULTS AND DISCUSSION

Clinical data

In view of the apparently cumulative effects of cigarette smoking and of occupational exposure to inhaled agents, the possible influence of tobacco smoking upon respiratory symptoms and pulmonary function should be taken into account. Therefore welders and controls were initially divided into smokers and non-smokers. Table I shows the mean, the standard deviation from the mean, age, height, weight and years of service of welders and the controls, and the mean duration of exposure of the welders. The differences between mean age and height of the welders and the controls in general and of the corresponding subgroups were not significant. The welders were usually in the older age group, ranging from 25 to 45 years with a maximum difference around 40 years, but the overall distribution of height as a function of age was similar in both groups. On average, the controls were heavier than the welders ($p<0.05$), as the mean weights of the corresponding subgroups were compared and differences were significant.

Table II. Relative frequency of case and control in terms of smoking.

Group	Welders		Controls	
	Mean	Percentage	Mean	Percentage
Total	100	100	50	100
Smokers	27	27	24	48
Non-smokers	73	73	26	52

The duration of exposure for the welders ranged from one to 40 years with an average of 20 years. The range of exposure for smoking and for non-smoking welders was similar, with means of 21 and 10 years, respectively. The smoking habits of the welders and the controls, as shown in Table II, were found to be identical.

The prevalence of respiratory symptoms and chronic bronchitis is summarized in Table II. The definitions of chronic cough, phlegm, asthma and bronchitis were given in the respiratory symptom questionnaire. Cough and phlegm were over twice as frequent among welders compared to controls (48% vs. 14%). Asthma was found to be confined to welders (19%), both smokers and non-smokers. Among welders, cough was more prevalent than in the controls ($p<0.05$).

On the whole, subjects with respiratory symptoms consumed more tobacco. Daily tobacco consumption was lowest among smokers with asthma and highest among ex-smokers with the same symptom. This can easily be understood since the occurrence of impairment is usually an important reason for giving up cigarette smoking.

Physiological data

The results of lung function measurements are summarized in Table IV. The mean values of pulmonary function parameters were different in welders and controls, with welders having lower values. The mean FEV_1 values in both smoking and non-smoking groups of welders were less than those of the corresponding groups of controls, and these differences were significant ($p<0.01$) between the two groups of non-smokers. The difference in forced vital capacity between the two groups of smokers, though lower

Table III. Relative frequency of respiratory symptoms in welders and controls (for smokers and non-smokers).

Symptom	Total		Smokers		Non-Smokers	
	Welders (%)	Controls (%)	Welders (%)	Controls (%)	Welders (%)	Controls (%)
Cough	32	24	44	29	29	25
Phlegm	48	14	52	17	49	15
Asthma	23	8	19	8	26	10
Rales	18	4	19	4	19	5

Table IV. Summary and comparison of lung function measurements in welders and controls.

Symptom		Total		Smokers		Non-Smokers	
		Welders	Controls	Welders	Controls	Welders	Controls
VC	Mean	3.60	3.92	3.75	3.93	3.55	3.91
	SD	0.61	0.82	0.655	0.639	0.59	0.98
FVC	Mean	3.71	4.07	3.79	4.08	3.68	4.06
	SD	0.66	0.87	0.674	0.710	0.66	1.01
FEV_1	Mean	2.97	3.35	3.02	3.38	2.94	3.34
	SD	0.51	0.71	0.475	0.521	0.53	0.87
$FEF_{75\%-85\%}$	Mean	0.94	1.91	0.91	1.10	0.95	1.20
	SD	0.58	0.46	0.572	0.369	0.59	0.54

forwelders(3.75vs.3.93),wasnotsignificant.Thedifference was more marked (3.55 vs. 3.91) between the two groups of non-smokers and of borderline significance ($0.05<p<0.1$). Respiratory function measurements for all subjects showed that respiratory impairment (restrictive pattern, obstructive pattern, or both) was more prevalent among welders (22%) compared to controls (12%) ($p<0.05$). In this case, t-test showed the mean value of pulmonary function parameters (VC, FVC, FEV_1, $FEF_{75-85\%}$) to be less among welders than the control group. These differences were significant ($p<0.05$). The radiography results indicated that the percentage of abnormal X-ray patterns (assidrosis) was higher among welders (22%) than among the control group (8%). Meanwhile, the results obtained from the McNimar test showed that abnormal lung function correlated with an abnormal radiography.

The Cockran test showed that in non-smokers, the prevalence of respiratory disorder symptoms including cough, sputum, dyspnea, and wheezing was higher among welders than the control group ($p<0.05$).

Concerning pulmonary function parameters in both groups (case and control) (VC, FVC, FEV_1, $FEV_{75-85\%}$), the first three variables have a negative correlation with age and a positive correlation with height ($p<0.00001$), while $FEF_{75-85\%}$ showed a negative correlation with age (p_{case} 0.007-p_{ctr} 0.004). The results obtained from the function measurements were analyzed by multiple regression equations.

Table V. Regression equations of respiratory parameters in case and control groups.

Parameter	Group	Regression equation	p
VC	Welders	0.044H-0.038A-2.167	0.00001
	Controls	0.058H-0.55A-3.918	0.00001
FVC	Welders	0.044H-0.039A-2.144	0.00001
	Controls	0.056H-0.053A-3.61	0.00001
FEV_1	Welders	0.030H-0.032A-0.807	0.00001
	Controls	0.047H-0.045A-3.092	0.00001
$FEF_{75\%-85\%}$	Welders	1.623-0.018A	0.007
	Controls	2.095-0.025A	0.004

The results of this analysis are presented in Table V. The increasing prevalence of respiratory disorders and the decrement in pulmonary function parameters among welders proved that exposure to welding fumes can cause chronic bronchitis.

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