Pulmonary Adverse Effects of Welding Fume in Automobile Assembly Welders

Seyed Akbar Sharifian[1], Ziba Loukzadeh[2], Ahmad Shojaoddiny-Ardekani[2], and Omid Aminian[1]

[1] Department of Occupational Medicine, Tehran University of Medical Sciences, Tehran, Iran
[2] Department of Occupational Medicine, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

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Abstract- Welding is one of the key components of numerous manufacturing industries, which has potential physical and chemical health hazards. Many components of welding fumes can potentially affect the lung function. This study investigates the effects of welding fumes on lung function and respiratory symptoms among welders of an automobile manufacturing plant in Iran. This historical cohort study assesses 43 male welders and 129 office workers by a questionnaire to record demographic data, smoking habits, work history and respiratory symptoms as well as lung function status by spirometry. The average pulmonary function values of welders were lower relative to controls with dose-effect relationship between work duration and pulmonary function impairment. The prevalence of chronic bronchitis was higher in welders than controls. Our findings suggest that welders are at risk for pulmonary disease.

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Introduction

Welding is a metal-joining process which fusion is produced by heating to suitable temperatures and melting the metal (1). Welding is an important component in industry and National Institute of Occupational Safety and Health (NIOSH) in 1988 estimated that there are at least 2 million welders in the world (2).

The adverse health effects of welding come from chemical and physical hazards. Common chemical hazards include metal particles, fumes and gases (carbon monoxide, nitrogen oxide and ozone). Physical hazards include electrical energy, heat, noise, vibration and radiation (3,4). Therefore, welders are exposed to inhalation of a number of fumes and gases (5). Many researchers have evaluated the effects of welding fume inhalation on the lung function of welders, but there is disagreement among these studies. The majority of differences between findings in various studies are frequently due to bias from inclusion or exclusion criteria. Some the most important bias are smoking status of study subjects, time-weighted average of exposure time like history of employment in years and day-time exposure in hours per day, type of welding processes, existence and usage of protective measures (local or general ventilator, isolation of welding room in productive site) and protective devices (4,6). Automobile assembly factory is one of the major industries in Iran. Thousands of welders are employed to build the auto-body parts, equipment and equipment repair or maintenance.

Ambiguous results have been observed in the literature and to the best of our knowledge, there are only few studies regarding respiratory effects of welders' exposure in Iran. So, the aim of present study was to evaluate the effects of welding fumes on lung function and respiratory symptoms.

Materials and Methods

This historical cohort study was performed from Jan to Aug 2007 on 43 male welders and 129 male office workers in an automobile assembly factory in Tehran, Iran. This study was performed in accordance with the declaration of Helsinki and subsequent revisions, and approved by the Ethics Committee at Tehran University of Medical Sciences, Iran. Written informed consents were obtained before entering the study. Subjects with known history of acute or chronic respiratory diseases and past occupational activities with exposure to asbestos, silica, paints and solvents, were excluded from the study. Welders divided according to their work duration (≥5 or <5 years) in to high exposure (n=23) and

Corresponding Author: Ziba Loukzadeh
Department of Occupational Medicine, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
Tel: +98 351 6229192, Fax: +98 351 6229194, E-mail: dr.loukzadeh@gmail.com

low exposure (n=20) groups. Necessary data was gathered using questionnaire and doing spirometry. The questionnaire included demographic data, work history, smoking habit and questions regarding respiratory symptoms as below: "Did you suffer from cough, sputum, wheeze or dyspnea at least once a week in the past three months?" Symptoms of chronic bronchitis were defined as having cough with sputum at any time during the day or night for at least three months of the year and for at least two consecutive years. Spirometry was performed using a calibrated portable spirometer (Spirolab II, MIR Co., Italy) at a fixed time of the day (8.00 am to 12.00 pm) and according to the American Thoracic Society criteria (7). We measured forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), 25-75% forced expiratory flow ($FEF_{25-75\%}$), peak expiratory flow rate (PEFR) where all expressed as a percentage of the predicted value and FEV_1/FVC ratio. Maneuvers were performed in a standing position with a nose clip and disposable mouth pieces were used for each person.

Data was analyzed by SPSS software version 11.5 (SPSS, Inc., Chicago, IL). An unpaired Student's t-test with a two-sided p-value was used to compare continuous variables between groups by estimating the mean ± SD. We used Chi-squared tests to compare differences in the symptoms. Odds ratios with 95% confidence interval were calculated with Mantel-Hanszel method. Linear regression analysis was used to control the effects of potential confounders on the association between welding exposure and lung function variables. Logistic regression analysis was used to control the effects of potential confounders on the association between exposure group and respiratory symptoms. P-values ≤ 0.05 were considered significant.

Results

Demographic details and lung function data of welders and office workers are shown in Table 1.welders were significantly younger and had less work duration compared to office workers. Three (7%) of welders used cigarette, compared to 31(24%) of office workers (*P* =0.01). Respiratory function results showed that the averages of all lung parameters of welders were lower than controls, but the difference of means was significant for $FEF_{25-75\%}$.

Average FEV_1 and FEV_1/FVC was lower in high exposure welders than low exposure welders significantly (*P*=0.04 and 0.01 respectively) (Table 2). Lower values were found for $FEF_{25-75\%}$ in high exposure arc welders than in low exposure group (*P*=0.06).

Clinical findings among welders and office workers are summarized in Table 3. Respiratory symptoms were more frequent among welders after adjusting for cigarette smoking, but the difference was significant for symptoms of chronic bronchitis (*P*=0.02). Respiratory symptoms were more common in high exposure welders than low exposure group, but the difference was not meaningful.

In linear regression analysis (Table 4), after adjusting for other factors, welding exposure was significantly associated with decreased $FEF_{25-75\%}$ (*P*=0.03). Moreover, work duration significantly associated with decreased FEV_1, FEV_1/FVC and $FEF_{25-75\%}$ (*P*-values are 0.004, 0.003 and 0.001 respectively). There was no association between pulmonary function and probable confounding factors such as age and cigarette smoking.

Table 1. Demographic data and pulmonary function values in welders and controls

	Welders (n=43) (Mean±SD)	Controls (n=129) (Mean±SD)	*P*-value
Age (year)	28.3 ± 3.0	34.7 ± 6.8	<0.01
Work duration (year)	5.7 ± 3.0	9.9 ± 5.8	<0.01
FVC(%pred)	94.9 ± 10.6	95.5 ± 9.2	0.67
FEV_1 (%pred)	94.6 ± 9.9	95.3 ± 9.2	0.37
FEV_1/FVC	82.5 ± 4.6	83.4 ± 4.5	0.29
$FEF_{25-75\%}$	86.1 ± 15.5	91.1 ± 18.4	0.04
PEFR (%pred)	87.5 ± 11.9	88.1 ± 18.8	0.8

Table 2. Demographic data and pulmonary function values in high- and low exposure welders

	High exposure welders (n=23) (Mean±SD)	Low exposure welders (n=20) (Mean±SD)	*P*-value
Age (year)	29.8 ± 3.0	26.6 ± 1.50	<0.01
Work duration (year)	7.5 ± 3.0	3.6 ± 0.8	<0.01
FVC(%pred)	95.0 ± 8.6	99.3 ± 12.4	0.19
FEV_1 (%pred)	91.8 ± 9.1	97.8 ± 10.0	0.04
FEV_1/FVC	80.9 ± 3.4	84.4 ± 5.2	0.01
$FEF_{25-75\%}$	82.1 ± 14.9	90.8 ± 15.2	0.06
PEFR (%pred)	85.5 ± 12.2	89.8 ± 11.2	0.24

Table 3. Prevalence of respiratory symptoms in welders and controls

Respiratory symptoms	welders n (%)	controls n (%)	OR* (95% CI)	AOR** (95% CI)	*P*-value
Cough	7 (16.3)	23 (17.8%)	0.90 (0.35-2.26)	1.20 (0.45-3.18)	0.82
Sputum	8 (18.6)	21(16.3)	1.75 (0.48-2.89)	1.55 (0.6-3.97)	0.72
Dyspnea	1 (2.3)	4 (3.1)	0.74 (0.08-6.85)	1.28 (0.11-14.50)	1.00
Wheeze	5 (11.6)	8 (6.2)	1.99 (0.61-6.45)	2.09 (0.63-6.90)	0.31
Chronic bronchitis	5 (11.6)	3 (2.3)	5.52 (1.26-24.40)	9.71 (1.65-55.50)	0.02

* OR=Odds Ratio

** AOR=Adjusted Odds Ratio for smoking

In logistic regression analysis, welding exposure was associated with chronic bronchitis (*P*=0.007). Cigarette smoking was significantly associated with cough and sputum (*P*-values are 0.002 and 0.01 respectively).

Discussion

There are many respiratory problems that may associate with welding. They include metal fume fever (most frequent acute respiratory complaint), asthma, chronic bronchitis, increased frequency and severity of respiratory tract infections, pneumoconiosis (uncommon), potential risk for lung cancer and alteration of lung function tests (1,4). Inhalation exposure to welding fumes is special, because welding fumes are a complex mixture of toxic fumes and noxious gases (4).

Our study confirms the findings of others suggesting that welding exposure adversely affects pulmonary function (3, 5, 6, 8-10). Several studies (11-13) have indicated no overall effect of welding on lung function relative to controls. The conflicting results in welders could be caused by differences in cigarette smoking habit, exposure to asbestos, workplace, welding materials, amount of ventilation and the kind of respiratory protection devices taken (6).

Consistent with our findings, Kilburn *et al*. and Wolf *et al*. found a significant decrease in $FEF_{25-75\%}$ in welders than controls (14,15). Our study also demonstrated a decrease in mean FVC, FEV_1, FEV_1/FVC and PEFR in welders, but the difference from controls was not statistically significant. This may be partially due to low sample size of welders.

Resembling to some other investigation (3, 6, 16-18), the present study shows a dose-effect relationship between welding duration and decreased pulmonary function. Welders with exposures longer than five years showed a significant reduction in FEV1, FEV1/FVC and $FEF_{25-75\%}$ relative to low exposure welders. Using regression analysis, we showed that increase in work duration decreased the pulmonary function values, too. This is in contrast to findings of studies accomplished by Ozdemir *et al*. (10) and Rossignol *et al*. (11) where no effects was seen in work duration.

The association between welding exposure and development of respiratory symptoms has been studied in many surveys (5, 8, 16, 19) and most investigations have showed a higher prevalence of respiratory symptoms in welders (3, 10, 15). It is likely because accumulation of welding particles in airways can increase mucus production and leads to stagnant secretion (15).

Table 4. Linear regression analysis of pulmonary function

	FVC	FEV_1	FEV_1/FVC	$FEF_{25-75\%}$	PEFR
Intercept	101.70 ± 4.00 (<0.0001)*	98.80 ± 3.90 (<0.0001)	85.70 ± 1.90 (<0.0001)	94.08 ± 7.36 (<0.0001)	81.82 ± 7.51 (<0.0001)
Age	0.007 ± 0.10 (0.96)	0.12 ± 0.13 (0.35)	0.01 ± 0.06 (0.87)	0.24 ± 0.25 (0.35)	0.35 ± 0.26 (0.18)
Smoking	-1.06 ± 1.97 (0.59)	-1.80 ± 1.90 (0.34)	-0.76 ± 0.92 (0.41)	-1.31 ± 3.56 (0.71)	-2.65 ± 3.62 (0.46)
Welding exposure	-0.24 ± 0.94 (0.80)	0.95 ± 0.90 (0.29)	0.88 ± 0.43 (0.14)	3.62 ± 1.69 (0.03)	-0.18 ± 1.73 (0.92)
Work duration	-2.90 ± 2.00 (0.14)	-5.60 ± 1.90 (0.004)	-2.85 ± 0.93 (0.003)	-11.89 ± 3.63 (0.001)	-2.53 ± 3.69 (0.49)

* Parameter estimate ± standard error (*P*-value)

The specific agents causing these findings are not known exactly, although significant levels of different toxic gases (carbon monoxide, ozone, nitrogen oxides) may be found during common welding processes (4). In this investigation, after adjusting for smoking, cough, sputum, wheeze and dyspnea were more frequent among welders, but association was not statistically significant. This study in accordance to other investigations (15, 20) has found that chronic bronchitis was significantly more frequent in welders compared to controls. Bradshaw *et al*. (8) have showed chronic bronchitis was more common in welders and found that smoking as well as exposure to welding fumes were independent risk factors for it. Like our study, Erkinjuntti *et al*. found that chronic bronchitis was much more common among welders (p-value=0.02); they also showed that some respiratory symptoms were more often reported by welders than controls, but these differences were not meaningful statistically (13).

We found a significant relationship between smoking and cough and sputum. Our study together with other surveys found no significant association between other respiratory symptoms, decreased pulmonary function parameters and smoking (3, 9, 21). Some previous studies on welders suggest that there is a synergistic relation between the effects of smoking and welding, causing lung disease and increased respiratory symptoms (5, 8, 15, 18), but our subjects were young adults and pulmonary function may not still affected by cigarette smoking.

This survey was limited by being a retrospective study; therefore, prospective studies are needed to better clarify the nature of the observed association. On the basis of our findings, we recommend primary prevention for diminishing the adverse effects in welders by local ventilation, use of respiratory protective devices and smoking cessation as well as periodic medical surveillance by using a questionnaire specially about respiratory symptoms and spirometry that must be performed annually. In summary, this survey showed that welders are at risk for developing respiratory symptoms and decreased pulmonary function values.

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