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Comparative Study of Lung Functional Tests in Zahedan Welders

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Background: Welding is defined as linking two metals with a local conjunction in sufficient thermal, pressing and metallurgical condition. There are several methods for linking two metals in welding.
Objectives: Welding is one of the professional jobs in Iran, yet there have not been considerable studies on its harmful effects. The current study aimed to compare lung functional tests between welders and non-welders.
Patients and Methods: A descriptive-analytical study was done on 110 subjects including: 55 welders (as case group) and 55 non-welders (as control group) in Zahedan, Iran. Samples were selected non-randomly. All spirometric indices were examined in both groups and reported as Mean ± SD and analyzed by appropriate statistical tests by SPSS software.
Results: The data indicated that all measured spirometric indices decreased significantly ($P < 0.01$) in welders compared to the control group. Also, reverse relation was observed between welding history and lung functional tests ($P < 0.01$).
Conclusions: Fume inhalation resulted from metal welding can lead to inappropriate changes in lung tissue and respiratory complication which finally cause symptoms as asthma and chronic obstructive pulmonary disease.

Keywords: Electricity; Welding; Spirometry; Lung Capacity; Respiratory Function Tests

1. Introduction

Welding is defined as linking two metals with a local conjunction in sufficient thermal, pressing and metallurgical condition. Electrical arc welding is attributed as the most common method in industries. The temperature of the formed spark in electrical arc is 6500 to 7000˚C (1). The coverage of used metallic electrode contains lime or calcium oxide, calcium fluoride, sodium oxide, titanium, fibrous materials such as asbestos, silicon, sodium or potassium silicate. Welding process creates gases aerosols from alloy metals and metal oxides and other evaporated chemicals from melted metal and electrode in welding area. Most of these substances are released as fumes and contaminate welding environment which lead to destroying effects on welders and working environment. Welders consist one percent of the whole working force in industrial countries (2). Potential risks of these fumes become apparent on body tissues and organs. The most important complications of these fumes are on face, eyes and respiratory tract, though their penetration into the body and blood can cause complications on nervous and cardiovascular system. Finally their potential effects may appear as acute and chronic respiratory disturbances and carcinogenic effects. The released Nitrogen oxide in working environment may result in lung inflammation and infection, bronchitis and finally death. The released Ozone of welding can result in eye and nose stimulation along with headache and general stimulation, although its high concentration causes chest pain, impaired vision and pulmonary edema (2). Since released particles in welding are too small, they are inhaled easily, penetrate to distal parts of the lung and leave severe complication (2). Disorders caused by inhaled particles in the air appear on the respiratory tract as bronchitis, pneumonia and obstructive airway disease (3-6). Hannu studied occupational asthma formed in welders and measured forced expiratory volume in the first second and maximum expiratory flow in welders. Dyspnea was their most common respiratory complain, a considerable percentage of them had a level of asthma, and 62 percent suffered from other respiratory symptoms (7). Sobaszek studied welding acute effects and reported changes in lung functional tests of welders such as decrease of forced vital capacity, maximum expiratory flow and forced expiratory volume in the first second (8). Meo studied welding fumes and their effect on lung functional tests in Pakistani welders. They reported that forced vital capacity (FVC), peak expi-

Implication for health policy/practice/research/medical education:
In This paper, effect of welding fumes has been studied on lung function tests by spirometry. Potential risks of these fumes become apparent on body tissues and organs.

ratory flow (PEF), forced expiratory volume one second (FEV1) and ratio of FEV1/FVC in workers who were in contact with welding fumes for more than 9 years were less than those of the control group which may result to levels of airway obstruction (9). Bhumika studied spirometer parameters and respiratory symptoms abundance in welders, and revealed that these parameters in welders were different from those of the control group, which is related to duration of employment (10). A study on ship making welders showed symptoms such as phlegm and cough in them which were accompanied by respiratory airway obstruction. Also changes in spirometer indices were observed (11). Although welding is a professional job in Iran, there have not been a lot of studies on its effects.

2. Objectives

The aim of the current study was to assess inappropriate effects of welding fumes on spirometric indices.

3. Materials and Methods

This case-control and descriptive-analytical study was conducted on the welders dealing with stainless steel welding, other types of welding were not considered. Inclusion criteria were: age > 20 years, welding history > 3 years. Qualified welders participated in the study voluntarily. The subjects were interviewed and filled out the demographic form, then spirometer tests (by spirometer device Cardio touch 3000 made by Bionet company) included maximum ventilation volume (MVV), slow vital capacity (SVC) and FVC tests were done. Each test was repeated three times and the best result was recorded as the test result. The subjects who were diagnosed as chronic obstructive pulmonary disease (COPD) after initial tests and interview were excluded from the study. The spirometer tests were done at least one hour after starting the daily work. The control group included workers who did not have any encounter with welding. Case and control groups were matched for age and smoking.

3.1. Data Analysis Method

The result of spirometer indices were shown as mean ± standard deviation, SPSS software was employed, and data were analyzed by student t-test. Chi-square statistical test was used to compare respiration defect symptoms as cough incidence and asthma feeling.

3.2. Ethical Considerations

A written letter of consent was obtained from the subjects for contributing in the study and doing tests. They were free to quit whenever they wanted. Their names were kept confidential and results presented as statistical indices without stating any names in scientific forum. Required suggestions for health factors in occupational environment were presented to Welders Union. University research Ethic Committee approval was obtained for this particular issue.

4. Results

There wasn't any significant difference between two groups in demographic features (Table 1).

Table 1. Demographic Features of the Studied Subjects

Parameter	Welders, Mean ± SD	Control, Mean ± SD	P Value
Age, Y	34.1 ± 8.2	33.9 ± 5.8	0.97
Height, cm	172.6 ± 4.5	174.5 ± 4.3	0.052
Weight, kg	71.5 ± 11.4	76.8 ± 5.3	0.06
SBP, mmHg	118.7 ± 7.3	119.6 ± 4.6	0.4
DBP, mmHg	74.7 ± 8.8	76.6 ± 3.7	0.14
BMI, kg / m^2	23.2 ± 3.9	24.1 ± 1.3	0.067

As it is shown in Table 2, FVC, FEV1, the ratio of FEV1/FVC, PEF, PEF 25-75%, MVV, SVC, tidal volume (TV), inspiratory reserve volume (IRV) and expiratory reserve volume (ERV) in the welders group were significantly less than the control group ($P < 0.01$).

Table 2. Comparison of Volumes and Capacities Mean and Lung Functional Tests Between Welders and Control Group

Parameter	Welders, Mean ± SD	Control, Mean ± SD	P Value
FVC, L	3.01 ± 0.52	3.8 ± 0.4	0.008
FEV1, L	2.1 ± 0.45	3.1 ± 0.35	0.002
FEV1/FVC, %	68.8 ± 7.5	80.9 ± 3.3	0.003
PEF, L/S	4.2 ± 0.85	4.92 ± 0.8	0.007
PEF 25-75%, L	2.6 ± 0.57	3.5 ± 0.64	0.005
MVV, L/m	163.4 ± 36.4	192.1 ± 26.7	0.002
SVC, L	4.3 ± 0.72	5.01 ± 0.6	0.004
TV, L	0.48 ± 0.1	0.6 ± 0.1	0.015
ERV, L	1.2 ± 0.14	1.3 ± 0.1	0.012
IRV, L	1.96 ± 0.3	2.6 ± 0.4	0.015

Studying welding complications in the group under study showed that nearly one third had phlegm when waking up in the morning, and more than half of them felt asthma when walking fast or going up the stairs and suffered from Dyspnea. 60% of welders reported fever and lethargy when returning from vacation and resuming their job. Most (84%) of the studied welders were doing welding at least 8 hours per day. 40% of the welders suffered from coughing when waking up. Distribution of the lung functional tests in welders was analyzed according to their welding background and results showed a reverse relation between welding and the lung functional tests, that is when welding background increased, the lung functional tests decreased (Table 3).

Table 3. Relation of Lung Functional Test According to Welding History in Welders Group

	FVC, L	FEV1, l	FEV1/FVC, %
Spirman R	- 0.68	- 0.83	- 0.85
P Value	0.009	0.009	0.009

Distribution of the lung functional tests in the subjects under study was analyzed according to their body mass index (BMI). There was reverse relation between the FEV1, the ratio of FEV1/FVC, MVV and ERV with welders' BMI (Table 4).

Table 4. Correlation of Lung Functional Tests and BMI in the Studied Subjects

Parameter	BMI Rise	
	Welders Group, R (P Value)	Control Group, R (P Value)
FVC, L	- 0.2 (0.15)	0.2 (0.16)
FEV1, L	- 0.32 (0.02)	0.19 (0.18)
FEV1/FVC, %	- 0.28 (0.04)	0.03 (0.9)
PEF, L/S	0.02 (0.9)	0.2 (0.14)
MVV, L/m	- 0.28 (0.04)	0.21 (0.13)
ERV, L	0.27 (0.045)	0.24 (0.08)
IRV, L	- 0.02 (0.9)	0.17 (0.2)

Also there was reverse relation between the FEV1, the ratio of the FEV1/FVC, PEF, and the MVV, IRV and ERV with the age of welders (Table 5).

Table 5. Correlation of Lung Functional Test and Subjects' Age in Studied Groups

Parameter	Age Rise	
	Welders Group, R (P Value)	Control Group, R (P Value)
FVC, L	- 0.2 (0.15)	0.02 (0.86)
FEV1, L	- 0.49 (0.009)	- 0.16 (0.25)
FEV1/FVC, %	- 0.69 (0.009)	- 0.56 (0.009)
PEF, L/S	- 0.55 (0.009)	- 0.23 (0.09)
MVV, L/m	- 0.39 (0.003)	- 0.2 (0.12)
ERV, L	- 0.38 (0.004)	- 0.71 (0.009)
IRV, L	- 0.46 (0.009)	0.14 (0.29)

5. Discussion

The result of the study revealed that welding causes changes in respiratory system and affects respiratory volumes and capacities and lung functional tests. Additionally these changes depend on the length of the contact with the particles. This job accompanied side-effects which are the result of encountering with the welding fumes. The common complaints of the welders were cough, asthma, morning phlegm, fever and lethargy particularly after returning from vacation (12). Hannu et al. also reported asthma as the most common complaint in welders (7). According to table 4 forced vital capacity mean, forced expiratory volume in the first second, the ratio of the forced expiratory volume in the first second to the forced vital capacity, maximum expiratory flow, the maximum volume of air per minute, slow vital capacity, current volume, inspiratory and expiratory reserve volume in the welders group were significantly less than those of the control group ($P < 0.01$). Decrease of forced vital capacity, forced expiratory volume in the first second, and the ratio of forced expiratory volume in the first second to forced vital capacity in the welders indicated structural alternation in the lung tissue which identifies level of airway obstruction in these subjects. These results were in accordance with the study of Christianon welders (1). Also Meo showed decrease of lung functional tests in Pakistani welders in comparison to those of the control group (9). Similar result is reported inJohn`s study on the welders of a car manufacturing factory (5). Bhumika studied the welders in a ship building industrial factory and reported decrease of lung functional tests (10). Previous studies reported decrease of lung functional tests and changes in chest X-ray in welders (13, 14). The decrease of the lung functional tests result had a reverse relation with welding history (Table 3). This reverse relation between occupational background and lung functional tests was also reported in the study done by Bhumika (10). Also the mean of FEV1, FEV1/FVC, and the quantity of MVV and ERV in the welders had a significant relation with their MBI (Table 4). The decrease of MVV quantity in the welders in comparison to those of the control group was reported by Meo (9). In addition, FEV1, FEV1/FVC, PEF, MVV, IRV, ERV in the welders had a reverse and significant relation with their age (Table 5). It seems that PEF decrease in the welders in comparison to those of the control group is a sign of lung general capacity decrease, because it is one of the most important factors which affects the maximum air flow. MVV alternation in the studied welders in comparison to those of the control group show the decrease of respiration system capability for producing sufficient lung airway in difficult conditions, which is one of the alternations found in lung because of contact with the welding pollutants. Histopathology alternations in bronchitis and lung of rat after encountering with welding fumes are reported by Stoleski (6). Furthermore the quantity of inspiratory and expiratory reserved volume in welders was less than those of the control group which is an approval of the created alternations in elastic membrane of lung tissue. More than 50% of the studied welders suffered from asthma while walking fast or going up the stairs which is an approval of the obstructive alternations in their airway. Smoking can be effective on these alternations but the percentage of the smokers was identical in the two groups to decrease the effect of this factor.

Inhalation of welding fumes can cause detrimental alternations in lung tissue of welders as well as respiration complication which lead to asthma and lung chronic obstructive diseases. Adequate mask use may preserve welder against these particles.

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Authors' Contribution

Gholamreza Komeili was main designer and corresponding author and he was participated in this reaserch 65 %, Ramezan Mirzaee was co-designer by 20 % participating, Sima Nabizadeh Sarabandi was coauthor by by 15 % participating.

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