Original Article

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ISSN: 1735-0344 *Tanaffos 2021; 20(1): 64-70*

TANAFFOS

Effects of Simultaneous Exposure to Smoking and Welding Fume on Pulmonary Function Tests in Spot Welders

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Received: 6 February 2020
Accepted: 22 June 2020

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Background: The respiratory effects of fume exposure during spot welding may aggravate some environmental risk factors such as tobacco smoking. Fume exposure and smoking have negative effects on pulmonary function tests (PFTs). This study assessed the simultaneous effects of smoking and welding fume on spirometry tests in spot welders.

Materials and Methods: This cross-sectional study was conducted on 667 spot welders and 1000 assemblers in an automotive manufacturing plant. Spirometry was carried out on all the participants under standard conditions and according to the American Thoracic Society Clinical Practice Guidelines and indices including FEV1, FVC, FEV1/FVC, FEF 25-75, and PEF were measured and compared between two groups of the study population including workers of spot welding and assembling.

Results: It was found that the effect of simultaneous exposure to smoking and welding fume was aggravated on the PFT indices including the FEV1 percent, FEV1/FVC, the FEV1/FVC percent, the PEF percent, FEF25-75, and the FEF25-75 percent, but not on indices such as FVC, the FVC percent, and PEF.

Conclusion: Simultaneous exposure to smoking and welding fume resulted in a reduction in some spirometry indices, causing respiratory airway obstruction in the spot welders. Occupational safety and regular medical examinations with shorter intervals in smoking spot welders can prevent acute respiratory effects of exposure to smoking and welding fume.

Key words: Occupational hazards; spot welding; smoking; pulmonary function tests

INTRODUCTION

Spot welding is a special welding process, in which metal pieces are joined together and an electric current passes between them (with the time interval between 0.01-0.63 second) (1). This may be performed manually in car service or manufacturing centers (2). Although multiple studies have been conducted on occupational diseases, few studies have been carried out on the respiratory complications of spot welding (3). Some studies have shown the respiratory effects of occupational pollutants (4, 5). However, available studies in this area have mainly focused on acute adverse effects and there are few studies on long-term hazardous effects (5-7). Studies have examined different aspects of occupational hazards and there are some debates about the acute and chronic respiratory effects of welding fumes (8, 9). Some studies have shown the association between restrictive and obstructive disorders with spot welding (10, 11). The coexistence of some other environmental risk factors such as tobacco smoking is a common problem and may

aggravate the respiratory effects of fume exposure during spot welding and cause negative effects on pulmonary function tests (12, 13). Pulmonary function tests including FEV1, FVC, FEV1/FVC, and PEF are the main respiratory parameters used to assess the effects of simultaneous exposure to spot welding and smoking (10). Accordingly, this study aimed to assess the effect of simultaneous exposure to smoking and welding fume on spirometry tests in spot welders in an automotive manufacturing plant.

MATERIALS AND METHODS

This cross-sectional study was conducted on workers of an automotive manufacturing plant during periodic occupational medicine monitoring. According to the results of the periodic assessment, the welding fume exposure value in the spot welding shop was lower than the permissible exposure limit. All the spot welders (667 cases) were enrolled as an exposure group. Additionally, 1000 out of around 3000 assemblers responsible for periodic monitoring without exposure to respiratory pollutants were enrolled. Members of the non-exposure group were selected using the simple random sampling method. Subjects with history of cardiac or respiratory disorders were excluded.

Confidentiality was guaranteed through anonymous data gathering and the study was approved by the Ethics Committee of the University of Tehran.

Data including age, height, weight, BMI, literacy, working years, weekly working hours, and smoking history were obtained from the patients' medical documents. A single expert and trained physician performed spirometry using the MIR Spirobank spirometer according to the American Thoracic Society Clinical Practice Guidelines and indices including FEV1, FVC, FEV1/FVC, FEF25-75, and PEF were measured and compared between the two groups. The height was measured without shoes with a standard stadiometer and the Seca medical column scale was used to measure the weight. All the tools were calibrated at the beginning of each examination day.

Statistically analysis

The normality distribution of the variables was checked with the Kolmogorov–Smirnov test.

Data analysis was performed using SPSS version 18.0. The numerical data were explored as mean (standard deviation) and the categorical data were presented as frequency and percent. Assessments were carried out using independent-sample-T, non-parametric equivalent (the Mann–Whitney U), and ANOVA tests. A two-way ANOVA test was used to understand whether there was any correlation between smoking and welding fume exposure as two independent variables.

P-values less than 0.05 were considered statistically significant.

RESULTS

This study was conducted on 1667 male subjects including 1000 assemblers and 667 spot welders with the mean age of 33.9±3.49 years. Of all the subjects, 440 were smokers, with 222 cases (33.3%) being from the spot welders and 218 cases (22.4%) being from the assemblers. . The mean age was 33.1±3.65 years among the assemblers and 35.09±3.35 years among the spot welders, and the difference was statistically significant (P-value=0.000). However, the mean age was not statistically different between the smokers (33.7±4.0 years) and the non-smokers (34.٠3±3.9 years). The mean total work experience was 9.4±3.71 years and the mean work experience was statistically different between the assemblers with 8.8±3.47 years and the spot welders with 10.3±3.87 years (P-value=0.000). The mean work experience was also significantly different between the smokers and the non-smokers (9.01±3.70 and 9.6±3.70 years, respectively, P-value=0.002). The mean total height was 175.64±6.30 cm with the mean height being 175.79±6.38 cm in the assemblers and 175.43±6.18 cm in the spot welders, without significant difference. Moreover, the mean height

was 176.15±6.17 cm and 175.47±6.34 cm in the smokers and the non-smokers, respectively, without significant difference. The mean total weight was 80.37±12 kg and the mean weight was 79.73±12.1 kg in the assemblers and 81.31±11.7 kg in the spot welders, with statistically significant difference (P-value=0.009). However, the mean weight was not meaningfully different between the smokers (80.84±13 kg) and the non-smokers (80.21±11.5 kg) (Table 1).

The subjects were divided into assemblers and spot welders with respect to their professions and FVC, FEV1, FEV1/FVC, PEF, and FEF25-75 were compared between the two groups using a t-test (Table 2). The predicted values (the ratio of each parameter to predicted amount) were used to compare each parameter between the groups after controlling for the effects of age and height on the spirometric parameters and the index shown as percent in the table. The predicted value was determined using the formulae in the NHANSIII study.

Table 1. Demographic characteristics of the study population

Study population	Age (Years) Mean (SD)	Working experience (years) Mean (SD)	Height (cm) Mean (SD)	Weight (Kg) Mean (SD)
Spot welders	35.09±3.35	10.3±3.87	175.43±6.18	81.31±11.7
Assemblers	33.1±3.65	8.8±3.47	175.79±6.38	79.73±12.1
P value	< 0.001	< 0.001	0.26	0.009
Smokers	33.7±4.0	9.01±3.70	176.15±6.17	80.84±13
Non smokers	34.03±3.9	9.6±3.70	175.47±6.34	80.21±11.5
P value	0.24	0.002	0.05	0.37

Table 2. Spirometric data in subjects according to job

Variables	Job Type	Number	Mean	Std. Deviation	P value
FVC	**Assembling**	870	4.97	0.63	0.120
	Welding	579	4.91	0.67	
FVC percent	**Assembling**	870	0.94	0.09	0.440
	Welding	579	0.94	0.10	
FEV1	**Assembling**	870	3.90	0.52	0.003
	Welding	579	3.81	0.54	
FEV1 percent	**Assembling**	870	0.91	0.10	0.080
	Welding	579	0.90	0.10	
FE1/FVC	**Assembling**	870	78.54	5.29	0.007
	Welding	579	77.76	5.42	
FEV1/FVC percent	**Assembling**	870	0.96	0.65	0.100
	Welding	579	0.96	0.67	
PEF	**Assembling**	870	9.39	1.45	0.020
	Welding	579	9.20	1.48	
PEF percent	**Assembling**	870	.93	.140	0.040
	Welding	579	.92	.14	
FEF25-75	**Assembling**	870	3.61	.92	0.001
	Welding	579	3.45	.89	
FEF25-75 percent	**Assembling**	870	.86	.21	0.06
	Welding	579	.84	.21	

As observed in the table, the spirometry indices including FEV1, FEV1/FVC, PEF, and PEF had obviously lower values in the spot welders than in the assemblers. The subjects were also divided into smokers and non-smokers and the mentioned parameters were compared in them using a t-test. The analysis results are shown in Table 3.

According to the results shown in Table 3, the spirometry indices including FEV1/FVC, FEV1, FEV1/FVC, PEF, PEF, FEF25-75, and FEF25-75 had significantly lower values in the smokers than in the non-smokers

To examine the effect of smoking and welding fume on the pulmonary function indices, a two-way ANOVA test was used. The results are shown in Table 4.

As observed in Table 4, simultaneous exposure to welding fume and smoking had an increased detrimental effect on PFT indices including FEV1, FEV1/FVC, FEV1/FVC, PEF, FEF25-75, and FEF25-75. However, this effect was not observed on some of the indices including FVC, FVC, and PEF.

Table 3. Spirometric data in subjects according to smoking

	Smoking	N	Mean	Std. Deviation	P value
FVC	**No**	1054	4.94	.64	0.360
	Yes	378	4.97	.67	
FVC percent	**No**	1054	.94	.09	0.630
	Yes	378	.94	.10	
FEV1	**No**	1054	3.87	.52	0.670
	Yes	378	3.85	.56	
FEV1 percent	**No**	1054	.91	.10	0.040
	Yes	378	.90	.11	
FEV1/FVC	**No**	1054	78.46	5.28	0.005
	Yes	378	77.55	5.54	
FEV1/FVC percent	**No**	1054	.96	.06	0.004
	Yes	378	.95	.06	
PEF	**No**	1054	9.35	1.44	0.040
	Yes	378	9.18	1.53	
PEF percent	**No**	1054	.93	.14	0.003
	Yes	378	.91	.14	
FEF25-75	**No**	1054	3.58	.90	0.030
	Yes	378	3.46	.93	
FEF25-75 percent	**No**	1054	.86	.21	0.002
	Yes	378	.82	.20	

Table 4. Interaction between smoking and welding

		Smoking	Mean	Std. Deviation	P Value
FVC	**Assembling**	**Negative**	4.95	0.64	**0.685**
		Positive	5.01	0.59	
	Welding	**Negative**	4.90	0.64	
		Positive	4.93	0.73	
FVC percent	**Assembling**	**Negative**	0.94	0.09	**0.461**
		Positive	0.95	0.09	
	Welding	**Negative**	0.94	0.09	
		Positive	0.94	0.10	
FEV1	**Assembling**	**Negative**	3.88	0.52	**0.099**
		Positive	3.93	0.51	
	Welding	**Negative**	3.83	0.51	
		Positive	3.77	0.59	
FEV1 percent	**Assembling**	**Negative**	0.91	0.10	**0.030**
		Positive	0.92	0.10	
	Welding	**Negative**	0.91	0.10	
		Positive	0.89	0.11	
FEV1/FVC	**Assembling**	**Negative**	78.54	5.31	**0.014**
		Positive	78.49	5.28	
	Welding	**Negative**	78.31	5.23	
		Positive	76.67	5.65	

Table 4. Continued

		Smoking	Mean	Std. Deviation	P Value
FEV1/FVC percent	Assembling	Negative	0.96	0.06	0.014
		Positive	0.96	0.06	
	Welding	Negative	0.96	0.06	
		Positive	0.94	0.06	
PEF	Assembling	Negative	9.38	1.43	0.059
		Positive	9.38	1.55	
	Welding	Negative	9.32	1.47	
		Positive	8.98	1.49	
PEF percent	Assembling	Negative	0.93	0.13	0.039
		Positive	0.93	0.14	
	Welding	Negative	0.93	0.14	
		Positive	0.89	0.13	
FEF25-75	Assembling	Negative	3.61	0.92	0.029
		Positive	3.62	0.92	
	Welding	Negative	3.53	0.87	
		Positive	3.30	0.91	
FEF25-75 percent	Assembling	Negative	0.86	0.22	0.018
		Positive	0.85	0.20	
	Welding	Negative	0.86	0.21	
		Positive	0.79	0.20	

DISCUSSION

This study assessed the effect of simultaneous exposure to smoking and spot welding on spirometry indices. It was observed that simultaneous exposure to these two environmental pollutants had detrimental effects on the majority of the indices. Accordingly, FEV1, PEF, FVC, and FVC showed no significant alterations but PEF, FEV1/FVC, FEV1/FVC, FEV1, FEF25-75, and FEF25-75 showed significant changes.

Szarm et al. (14) in their systematic review in 2013 observed that simultaneous exposure to spot welding fume and smoking caused no changes in FEV1, which is in line with our findings. In another study, no correlation was observed between smoking and the respiratory effects of welding fume. Two studies showed that pulmonary function was not reduced in smoking spot welders. Moreover, no significant decrease was observed in pulmonary function test outcomes in 5% of spot welders after 3 years, and in contrast to our findings, smoking welders experienced a more decrease in FEV1 values.

In another study by Hariri et al. (15), spot welding led to a reduction in pulmonary function test outcomes (37% vs. 27%), compared to non-welding tasks. In their study, spirometry indices were more reduced in subjects with less than ten years of work experience, which may be due to their smoking habits. This is congruent with our findings.

Rahmani et al. (16) conducted a study on welders, 27 percent of whom were smokers. They reported a higher decrease in pulmonary function in those simultaneously exposed to fume and smoking than in others.

Loukzadeh et al. (17) conducted a study on Iranian spot welders and service employees. They reported that the welders had lower FEV1, FEF25-75, and FEV1/FVC values than the employees, which is not in line with our findings. They concluded that FEV1 did not significantly change but the other two indices significantly decreased with simultaneous exposure to welding fume and smoking. Luo et al. (18) in their cohort study showed that high fume exposure among arc welders led to several alterations in spirometry indices. As a limitation to our study, work experience as an indirect index of exposure time was

significantly different between the spot welders and the assemblers.

Roach (19) reported that simultaneous exposure to welding fume and smoking resulted in the reduction of pulmonary function test outcomes. In our study, we observed that FEV1, FEV1/FVC, PEF, and PEF had lower values in the spot welders than in the assemblers, showing that welding fume exposure may be the cause of the reduction in these indices. Moreover, it was observed that passive smoking resulted in obstructive airway responses and reduction in FEV1/FVC, FEV1, FEV1/FVC, PEF, PEF, FED25-75, and FEF5-75 values.

The results also revealed that simultaneous exposure to welding fume and smoking resulted in reduction in some of the spirometry indices including FEV1, FEV1/FVC, FEV1/FVC, PEF, FED25-75, and FED25-75. Moreover, the significant correlation between smoking and spot welding fume caused reduction in the pulmonary function indices. Hence, further monitoring of smoking spot welders with shorter intervals can prevent the acute respiratory effects of these two environmental pollutants. Controlling smoking habits in spot welders is also useful. Further studies are required on other factors aggravating respiratory complications in spot welders.

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