2015-5435/14/63-83-88
INTERNATIONAL JOURNAL OF OCCUPATIONAL HYGIENE

IJOH 7: 83-88, 2015

ORIGINAL ARTICLE

Peak Expiratory Flow Changes among Welders

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Received January 27, 2015; Revised April 16, 2015; Accepted June 22, 2015

This paper is available on-line at *http://ijoh.tums.ac.ir*

ABSTRACT

More than one percent of the labor force in each country consists of welders exposed to various damages caused by welding. The number of studies conducted in this field is low, especially in Iran. In this paper, we tried to discover any temporary and reversible obstructive effect of welding fumes on the respiratory systems of welders. In this cross-sectional study, peak expiratory flow rates and respiratory symptoms of 37 welders during work shift were evaluated. Peak expiratory flow rates of welders were recorded in three working days and one non-working day. Peak expiratory flow rates in working days were compared with non-working Peak expiratory flow rates as a control measure. PEF values were higher in every recorded time in non-working days than that of working days. Besides, PEF of the middle shift decreased an hour after end of the shift had increased. Changes in PEF since the start of shift until an hour after the shift had the same pattern in all four days, but in conflict with daily physiological patterns. Fewer people complained respiratory symptoms such as cough and sputum in non-working days. Therefore, exposure to the welding fumes can result in reversible and temporary effect on PEF and this could lead to bronchial irritation and cause respiratory symptoms. Therefore, it is recommended that welders use sufficient respiratory protection and weld in places with air ventilator specialty when welding with CO_2 in order to reduce irritant effects of welding fumes on respiratory systems.

KEYWORDS: *Peak Expiratory Flow (PEF), Welders, Respiratory diseases, Welding fumes, Respiratory symptoms*

INTRODUCTION

One of the most commonly used activities in different industries is welding. Approximately, more than one percent of the labor force in each country consists of welders [1]. There are (400000) welders in USA [2].

In Iran, a large number of workers are employed as professional welders. Approximately, all these people are exposed to various damages caused by welding. Their main risks come from inhalation. For this reason, in a large number of studies it has been mentioned that lung diseases among the welders are more common in comparison to others. Actually, respiratory effects caused by welding could be due to high concentrations of pollutants such as dust, chromium, nickel, iron oxide, manganese, carbon monoxide and nitrogen [3].

Respiratory damage can be different according to the existence of ventilation and use of respiratory protection equipment [4]. Moreover, welding time and the type of the metal that was applied can be effective [5].

Numerous studies have been conducted on lung injuries but the results of pulmonary analysis were not the same [4]. In some of the studies, there were no changes in spirometric indices in welders over the period of observation [6] and in the other studies the mean of the pulmonary functions parameters were below the average. For instance, Meo et al. [7] conducted a study on Pakistani

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welders and observed that mean parameters of pulmonary functions like FEV1, FEV1/FVC and PEFR were below the average. Welding exposures be considered as new causes of occupational asthma [8].

After reviewing the non-specific and immediate responses of the bronchus, welding exposures had acute and transient effects on the respiratory system [9]. It seems evaluating lung functions during shift work and comparing with non-working days can be a good indicator of welding fume effects on respiratory systems. Among different approaches, we can mention serial peak expiratory flow changes as a confirmation of the relationship between asthma with patient's occupation.

Changes in peak expiratory flow follow daily physiological circadian rhythm. As in the morning peak, expiratory flow rate was the lowest and gradually increased till the afternoon up to about 6 pm; it reached the highest level, and then continued as a plateau with a slight change till sleep time. The average percentage change in normal people in Aggarwal`s study was (7.23±2.98) (A%M) [10].

In spite of the large number of welders in Iran, there is no credible study regarding short-term and immediate effects of welding on respiratory status at hand. Therefore, in this survey, by studying the peak expiratory flow changes and respiratory symptoms of welders during the work shift and by comparing these changes of working days with non-working days, we tried to discover any temporary and reversible obstructive effect of welding fumes on respiratory systems.

MATERIALS AND METHODS

This study is cross-sectional (before-after type) carried out in an Isfahan Steel Factory in 2013. We surveyed all the 42 welders in that factory. This sample size was greater than in similar studies [11-14]. Their work shift was from 7:30AM to 5PM. All welders with history of at least one year welding job were considered eligible for this study. We explained the aim of this survey to them. All eligible welders agreed to participate in our study. After the evaluation of exclusion criteria (recent history of colds, pneumonia and asthma, exposure to paints, asbestos and silica, employment in the bakeries and construction sites as a second job) the 5 of them were excluded. Finally, we enrolled 37 welders in this study.

Demographic data and data related to work resume, history of smoking, respiratory symptoms, exposure to asbestos and silica in previous jobs and having second jobs such as masonry and bakery were gathered using a prepared checklist. Peak Expiratory Flow (PEF) rate of each welder was measured by the use of ambulatory personal peak flow meter. In order to obtain an accurate PEF, we used "PEF HS755EU-010" full range peak flow meter made by "Respironics Health Scan". This peak flow meter is personal ambulatory with a full measurement range of 60–810 liters per minute and 10 liters per minute resolution. Welders were trained about how to use a peak flow meter apparatus and after intensive training sessions and ensuring that the correct method was learned, they were provided with the devices. Welders were asked to use the device at specified times [1- before starting the shift (before 7:30), 2- in the middle of the shift (at 1pm) and 3- one hour after the end of shift (6 pm)] for 4 consecutive days (including the 5th day of work, 6th day of work, non-working day and 1st day of work). They were asked to write down the PEFs in the tables. Welders were also asked to fill respiratory symptoms questionnaire for each day of PEF measurement. Based on previous studies, each measurement consisted of three trials and the highest values in each measurement recorded by peak flow meter were selected and analyzed. Since this study had a before-after designed, measurement on a non-exposure day (holiday) was used as a control for each welder.

SPSS software (Chicago, IL, USA), Pearson correlation tests, ANOVA and t-test were used for analyzing the data that was gathered by the measurements.

RESULTS

Mean age of participants was 32.5±7.6 years. The youngest participant was 19 years old and the oldest was 55 years old. The average duration of employment as a welder was 10±7.8 years. The lowest period of job experience was one year and the longest was 40 years. About the welding type, 11 welders comprising (29.7%) used electricity for welding and 26 of them (70.2%) used CO_2. None of the welding stations had a local ventilation system and only some saloons had general ventilation system.

Information about other demographic data, having used masks or not, smoking or no smoking, existence of ventilation or non- existence are shown in Table1.

Peak flow was measured in each time (pre shift, middle of shift and one hour after the shift) for four days (included the 5th day of work, 6th day of work, non-working day and 1st day of work). We calculated the average of each time in every day separately.

Then, we compared the average of pre shift PEF in all four days with each other by using ANOVA test. The highest average was on non-working day and the lowest was on the last day of work. This difference was not statistically significant.

We computed the average PEF at the middle of the shift in four days. We compared them with each other by the use of ANOVA test. The highest average was on non-working day and the lowest was on the last day of work. This difference was not statistically significant.

The average PEF an hour after the end of shift was calculated and compared them with each other in four days by using ANOVA test. The highest average was on non-working day and the lowest was on the 5th day of work. This difference was not statistically significant.

Average PEF before the beginning of the shift on the 5th day of work was 505.4 (L/min) ± 95.06 and the average PEF at an hour after shift was 511.62(L/min)±93.34. The difference between them was not statistically significant.

Average PEF before the beginning of the shift on the 6th day of work was 503.4 (L/min)± 87.59 and the average PEF at an hour after shift was 512.97(L/min)±100.93. The difference between them was not statistically significant.

Average PEF before the beginning of the shift on the 1st day of work was 515.94(L/min)±72.39 and the average PEF at an hour after shift was 512.97 (L/min)±100.93. The difference between them was not statistically significant (P>0.05).

In this study, daily peak flow changes in four days were obtained. The daily changes were calculated using formula like in the previous studies [10, 15]. The highest was on the 1st day of work, which was 15.56%±11.5. On the 5th day, it was 14 .97% ±9.25 and 13.06%±9.13 on the 6th day. The lowest value was 10.06%±6.12 that occurred on a non-working day. The differences between them were not statistically significant.

$$\text{Daily changes} = \frac{\text{maximum value of peak flow-minimum value of peak flow}}{\text{Mean daily peak flow}}$$

As can be seen in Fig. 1, the changes in PEF since start of the shift till to an hour after the shift had the same pattern in every four days. However, these chaFfignges were not statistically significant and this pattern is different from the daily physiological pattern of PEF.

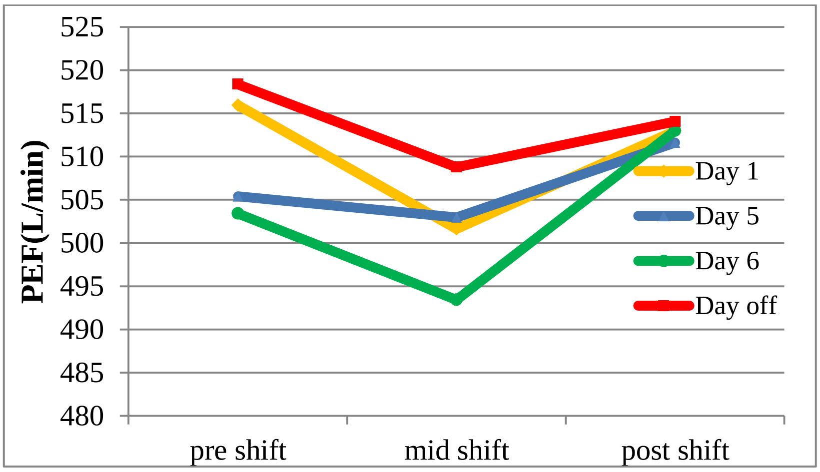

Fig. 1. Graph of welders Peak expiratory flow changes within 4 days

To survey the effect of mask on PEF value, we compared the average PEF at the middle of the shift in a group of welders who used masks with the group that did not use. PEF value was higher in the group that didn`t use masks than others in all three working days. However, this was not statistically significant.

Also, we compared PEF of one hour after shift in a group of welders that used masks with the group that didn`t use. PEF value was higher in the group that didn`t use masks than others in all three working days. This was not statistically significant.

In order to survey the effect of air ventilation on PEF value, we compared the average value of PEF at the middle of the shift in the group of welders that worked in places with ventilation against the group that worked in places with no ventilation using the T-test. As can be seen in table 3, PEF value was higher in welders who worked in ventilated places than others. This was not statistically significant.

Table 1. Demographic data

Variable	Yes N (%)	No N (%)
High school diploma	7(18.9)	30(81.8)
Smoking	12(32.4)	25(67.6)
Respiratory mask	22(59.5)	15(4.5)
Ventilation	17(45.9)	20(54.1)

Also, we compared PEF in an hour after end of shift in the group of welders that worked in places with ventilation against the group that worked in places with no ventilation by using t-test. As can be seen in table 6, PEF value was higher in two working days for welders who worked in places with ventilation than others. In one working day, this PEF value was lower in the welders who worked in ventilated places than others. This was not statistically significant.

To study the effect of type of welding on PEF value, we compared the average PEF at the middle of the shift in Arc welders with welders who used CO_2 by using t-test. As can be seen in table 4, PEF value was higher in Arc welders in two of the three working days than welders who used CO_2. However, this was not statistically significant.

In addition, we compared PEF in an hour after the end of shift in Arc welders with CO_2 welders by using T-test. PEF value was higher in Arc welders in all three working days than CO_2 welders. However, this was not statistically significant.

Respiratory symptoms of welders were examined during the working days. 19 of them (51.4%) complained about coughing and sputum production and 2 of them (5.4%) complained about asthma while the other 16 of them (43.2%) had no particular symptoms. But the rate of respiratory symptoms of the non-working days was reduced as only 9 of them (24.3%) complained about cough and sputum and 2 of them (5.4%) complained about asthma and the other 26 of them (70.3%) had no symptoms. By using Friedman test, we compared the existence of symptoms in working days with non-working days. This difference was statistically significant (P=0.046).

The relationship between duration of employment as a welder with mean peak flow before, and the beginning of the shift at 1st working day (as the base) was examined using Pearson correlation test, and the coefficient was calculated as (0.029) and that was not statistically significant.

Table 2. Comparing PEF between working days with non-working days

Days of week	5th Day of work Mean(L/min)±SD	6th Day of work Mean(L/min)±SD	Non-working day Mean(L/min)±SD	1st Day of work Mean(L/min)±SD	*P*-value
Beginning of the shift	505.4±95.06	503.4±87.59	518.37±87.73	515.94±72.39	>0.05
Middle of the shift	502.97±97.17	493.4±88.58	508.78±96.25	501.62±81.53	>0.05
After the shift	511.62±93.34	512.97±100.93	514.05±90.44	512.97±88.02	>0.05

Table 3. Comparing PEF based on existence of ventilation

Days of week	PEF at the middle of shift		PEF after shift	
	ventilation Mean(L/min)±SD	No ventilation Mean(L/min)±SD	ventilation Mean(L/min)±SD	No ventilation Mean(L/min)±SD
5th day of work	508.23±117.05	498.5±79.42	500±102.04	521.5±86.71
6th day of work	505.88±95.39	482.8±83.35	520.58±117.01	506.5±87.61
Non-working day	-	-	-	-
1st day of work	510.58±77.73	494±85.86	530.58±94.89	498±81.14

Table 4: Comparing PEF based on type of welding

Days of week	PEF at the middle of shift		PEF after shift	
	Arc welding Mean(L/min)±SD	CO_2 welding Mean(L/min)±SD	Arc welding Mean(L/min)±SD	CO_2 welding Mean(L/min)±SD
5th day of work	546±79.33	487.03±99.6	547±67.99	498.51±99.02
6th day of work	540±39.72	476.14±95.79	573±73.94	490.74±101.56
Non-working day	-	-	-	-
1st day of work	500±53.95	502.22±90.52	546±90.5	500.74±85.52

DISCUSSION

In Iran, a large number of workers are employed as professional welders and their main exposures are through inhalation. Respiratory effects caused by welding could be due to high concentrations of pollutants such as dust, chromium, ozone, nickel, iron oxide, manganese, carbon monoxide and nitrogen oxide.

The purpose of designing this inquiry was to study the peak expiratory flow changes and respiratory symptoms of welders during work shift and comparing them in working days and non-working days.

In this study, peak expiratory flow was measured and recorded 3 times a day (before the beginning of shift, in the middle of the shift and an hour after the end of shift) for 4 days (included 3 working days and a non-working day). Average PEF value in each time was calculated.

Then, we compared the average pre-shift PEF of the same time with each other in four days. Then, we did the same comparison for middle of shift and for an hour after shift. Although PEF values were lower in every time for working days than non-working days, none of these differences was statistically significant. Arc-welders had lower PEFR than the control group [16].

In the evaluation of daily changes of PEF on different days in this study, the PEF of the middle shift decreased an hour after the end of shift had increased. The changes in PEF since the start of shift till an hour after the shift had the same pattern in every four days of conflict with daily physiological pattern.

Many factors can be effective in making patterns like this in all four days even on a non-working day. It can be because of exposure to welding fumes from welding in working days and from welding activities outside of work program on a non-working day. Therefore, exposure to welding fumes may lead to a decrease of PEF in the middle of shift. This reduction was in conflict with circadian rhythm of PEF that led to an increase in PEF from morning till afternoon. As can be seen from the PEF value, rose had an hour after shift. In fact, it may be said that the effect of welding fumes was temporary and transient on airways. Here, an hour after the termination of exposure and reduction of airways response, PEF values increased. This increasing trend of PEF after the end of the shift is harmonic to the daily peak flow of circadian rhythm.

This finding was indicated in the other expressions of the study which was conducted by Donoghue et al; they compared welders with the control group. Peak flow of welders reduced after 15 minutes of beginning of the shift and it was stated that this reduction was due to immediate type of reaction in airways to the welding fumes [14].

Another notable point is that, percentage daily changes of PEF on working days were higher than of non-working days. The rate of changes on all 4 days in welders was higher than a similar value in Aggarwal's study about non-welders and that was stated as 7.23±2.98 [10]. This index was 3.48 in men and 3.86 in women [17]. Perhaps, welding fumes increased the airways reactions effectively.

In this study, our findings about the lack of sustainable effect of welding fumes on airways during the working shift were against results of some other studies [7]. He claimed that welding had chronic effects on airways and caused more obstructive patterns in spirometry [7], or another study that was conducted on the welders had indicated that welding fumes changed in spirometry [18]. But Bekett in a 3 years study on welders showed that welding was associated with reversible respiratory symptoms related to the work and with low and transient lung functions across-shift, but no growth in reactivity of the airways in welders was observed and this indicates that it is unlikely that welding fumes cause significant chronic effects on pulmonary functions [19].

As expected in our study, welders who worked in places with ventilation had higher PEF value than others in most of the measurements. But about the use of masks, the welders who used masks unexpectedly had lower PEF values than welders who didn't use them in most of the measurements. Some of the welders who used masks had lower peak flow values [14].

Therefore, both studies have common outcomes about inadequacies of the masks and false confidence in welders which resulted in their encounter with welding pollutants by using these masks. Also, it may be the reason behind the fact that welders after lung injuries and lung volume reductions started using masks in order to prevent further impacts. This finding indicated better respiratory protection and effective exhaust ventilation are needed during welding.

The PEF values in welders who used Arc-welding were higher than welders who used CO_2 to weld in most measured times. In CO_2 welding, the amount of an irritant gas like ozone was higher than other Arc-welding methods and that can result in this finding.

In our study, fewer people complained about respiratory symptoms such as cough and sputum on non-working days. Respiratory symptoms among welders were more than in other people [19-20] and another study mentioned higher prevalence of chronic bronchitis symptoms among welders than non-welders [5]. Therefore, exposure to the welding fumes can lead to bronchial irritations and could cause respiratory symptoms.

CONCLUSION

Welding fumes had effect on PEF and were probably temporary and reversible, but can lead to irritations of the respiratory system, cause cough and sputum. Therefore, it is recommended that welders use sufficient respiratory protection and weld in places with air ventilator specialty while welding with CO_2, to reduce irritant effect of welding fumes on the respiratory system.

ACKNOWLEDGEMENTS

The authors declare that there is no conflict of interests.

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