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Original

Occupational Exposure to Ultraviolet and Infrared Radiation in Welders

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Abstract

Background: Human beings are always exposed to natural and artificial sources of ionizing and non-ionizing radiation. Welding is one of the jobs whose professionals may expose ultraviolet and infrared radiation and suffer from the resulting complications. Therefore, the purpose of this study is to determine the exposure to ultraviolet and infrared radiation in welders. **Methods:** This study was conducted on 70 welders in Bojnord city. The UV meter and the IR meter (Hanger) were used to conduct measurements. The measurements were conducted at 10, 50 and 100-cm distances from the welding site, and at two heights, the wrists and eyes. Eye symptoms caused by radiation were collected and recorded by checklist and observation. Data were analyzed by descriptive statistics, t-test, and ANOVA. **Results:** The average age of the workers was 37(10) years, the average work experience was 18(11) years, and the average radiation exposure duration was 3.5(2) hours. The average ultraviolet radiation measured was 4.13(4.88) W/m2 and the average infrared radiation was 17.13(12.54) W/m2 at the welding stations. In 84% of the stations, the measured ultraviolet radiation and in 100% of them, the measured infrared radiation was standard. There were 58 (83%) welders with at least one eye problem. There was a significant relationship between the amount of radiation, and the type of welding, exposure duration, and work history, but no significant relationship between the amount of radiation and height and distance of measurement. **Conclusion:** In order to prevent eye symptoms in welders, it is recommended to reduce the duration of exposure of the welders or welders should do welding during the day intermittently and use suitable personal protective equipment, especially a suitable welding mask, during welding.

Keywords: Ultraviolet radiation; Infrared radiation; Occupational exposure; welding process

Introduction

Human beings are always exposed to natural and artificial sources of ionizing and non-ionizing radiation. With the advancement of technology in various fields, the use of radiation sources has increased extensively, thereby increasing the exposure of individuals to radiation.[1]The excessive use of electric power and high levels of energy in industrial processes result in the release of energy in the form of radiation in the course of transmission and conversion, which can have adverse effects on human health.[2] Exposure to infrared radiation and thermal damage caused by it leads to eye damage and cataract formation, so that infrared

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radiation is absorbed by the cornea and iris and the heat produced enters into the eye lens and ultimately cataracts are developed due to increased temperature in the eye lens.[3]

The ultraviolet radiation is another part of the spectrum of electromagnetic beams with a wavelength of 100 to 400 nm, with 280- to 400-nm wavelength causing comparably more severe damage to the skin and the eyes than other wavelengths.[4] Exposure of the eye to ultraviolet radiation can lead to cataracts and damage to the retina. In both cases, it is assumed that ultraviolet radiation can form free radicals, which results in changes in cellular protein and lipid peroxidation.[5] Exposure of people with ultraviolet radiation in everyday life is an inseparable part, and this is one of the most important risks for workers in open environments. Additionally, a wide range of artificial sources also has the ability to create intense exposure to ultraviolet radiation in the working environment.[6] Examples of industrial processes that are widely used in occupational environments are the welding process, which is itself a potential source of ultraviolet radiation, visible light, and infrared radiation.[7]

The intensity of the light emitted by the electric arc in the welding can damage the retina, while infrared radiation will cause corneal injury and lead to the development of cataracts.[8]In the study of Vatani et al., the exposure of welders at a distance of one meter was measured and estimated to be nearly standard.[9] In addition, the study of Kalantari et al. indicated that eye protection equipment significantly reduced the average exposure of workers to ultraviolet and infrared radiation.[10]

Understanding the hazards and adverse effects of harmful radiation and unpleasant effects caused by other harmful factors on humans have made it necessary to foresee safe technologies for each of these cases. Given the various hazards of welding operations and also the number of workers involved in this industry across Bojnord, it is essential that the hazards of this operation be well identified. Therefore, this study was conducted to investigate the exposure of welders to ultraviolet and infrared radiation.

Methods

The study population of this study consisted of all samples actively involved in welding process in Bojnord. Accordingly, in the summer of 2018, ultraviolet and infrared measurements were performed in 70 welding processes.

Measurements of ultraviolet and infrared radiation were conducted by using the UV meter and IR meter (Hanger) at 10, 50 and 100 cm distance from the welding site, approximately close to the body (wrist) and face (eyes).

In addition, eye symptoms caused by exposure to ultraviolet and infrared radiation include the sensation of having sand in the eye, blurred vision, severe eye pain, watering eyes, eye irritation, headache, eye sensitivity to light, color blurring or fading, and double vision was examined for and recorded in a checklist. After collecting data and carrying out necessary controls, information was entered into SPSS version 19 and the data were analyzed using descriptive statistics as well as t-test and ANOVA.

Results

In this study, 70 welding processes in Bojnord were studied, 50 (71%) of which were done with electricity and 20 (29%) were gas welding. With respect to work history, 13 (18%) had a work experience under 10 years old, 25 (36%) had a work experience of 10 to 19 years, 19 (27%) a work experience of 20 to 29 years and 13 (19%) had a work history of 30 years and over. With respect to age, 14 (20%) were less than 30 years old, 30 (43%) were 30-39 years, 14 (20%) were 40-49 years and 12 (17%) were older than 50 years old. In terms of duration of exposure, 10 (14%) had an exposure of less than 2 hours, 20 (29%) had an exposure 2 to 4 hours and 40 (57%) had an exposure of 4 hours or more Table 1.

Table 1. Number of welders based on the type of welding, work experience, age and exposure

Title		Number	Percentage
Type of welding	Electric	50	71
	Gas	20	29
Work experience (yr)	Less than 10	13	18
	10-19	25	36
	20-29	19	27
	30 and over	13	19
Age (yr)	Less than 30	14	20
	30-39	30	43
	40-49	14	20
	Over 50	12	17
Exposure (h)	Less than 2	10	14
	2-4	20	29
	4 and over	40	57

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Table 2. Ultraviolet and infrared radiation based on the location of measurement and distance

Title		Mean (W/m²)	SD
Ultraviolet radiation	The hand	4.17	4.90
	The eye	4.08	4.85
Infrared radiation	The hand	12.62	17.19
	The eye	12.45	17.01
Ultraviolet radiation	10 cm	4.22	4.93
	50 cm	4.13	4.89
	100 cm	4.04	4.85
Infrared radiation	10 cm	12.74	17.30
	50 cm	12.53	17.13
	100 cm	12.33	17.08

The average age of the workers was 37(10) years, the average work experience was 18(11) years, and the average radiation exposure duration was 3.5(2) hours. The results regarding ultraviolet and infrared radiation based on the location of measurement and distance are shown in Table 2.

Regarding eye symptoms, 4 (5.7%) had eye irritation, 2 (2.9%) had watering eyes, 1 (1.45%) had eye irritation and pain, 2 (2.9%) had watering eyes and eye pain, 4 (5.7%) had watering eyes and eye irritation, 1 (1.45%) had blurred vision and eye irritation, 2 (2.9%) had eye irritation and the sensation of having sand in the eye, 4 (5.7%) had eye pain, eye irritation, and blurred vision, 1 (1.45%) had watering eyes, eye irritation and blurred vision, 10 (14.5%) had the sensation of having sand in the eyes, watering eyes and eye irritation, 8 (11.4%) had the sensation of having sand in the eyes, eye pain, and watering eyes, 4 (5.7%) had watering eyes, eye pain and eye irritation, 1 (1.45%) had the sensation of having sand in the eyes, eye irritation and blurred vision, 14 (20%) had the sensation of having sand in the eyes, eye irritation, and blurred vision, and 12 (17.1%) had no symptoms. Overall, 58 (83%) of welders had at least one eye problem Table 3.

There was a significant relationship between the amount of ultraviolet radiation and exposure duration (P=0.000) and work experience (P=0.015), as well as a significant relationship between the amount of infrared radiation, and exposure duration (P=0.000) and work experience (P=0.011). The average amount of ultraviolet radiation measured in welders with at least one eye problem was 4.85 (5. 01) W/m2 and in welders with no eye problems 1.68(0.64)W/m2, with a significant difference according to t-test (P=0.000). The average amount of infrared radiation measured in welders with at least one eye problem was 14.22 (17.7) W/m2 and in welders with no eye problem 10.34(4.41) W/m2, with a significant difference according to t-test (P=0.000).

Discussion and conclusion

The average ultraviolet radiation measured was 4.13(4.88) W/m^2 and the average infrared radiation was 17.13 (12.54) W/m^2 at the welding stations. In 84% of the stations, the measured ultraviolet radiation and in 100% of them, the measured infrared radiation were standard, which is consistent with the study of Vatani et al. [9] Regarding the amount of infrared radiation, our results are not consistent with the results of Majidi et al.[11] which could be due to the different types of jobs and the process of work (casting industry). Regarding the exposure to infrared radiation, our results are consistent with the study of Ali Abadi et al., and regarding the amount of ultraviolet radiation, our results are consistent with that study because of the voltage amount and type of electrode used.[12] In the study of Zamanian et al., in which the exposure of welders to ultraviolet radiation was studied, the exposure was higher than the limit, which is not consistent with the results of our study.[13] There was a significant correlation between the amount of ultraviolet radiation, and exposure duration and work experience. As the exposure duration and work experience increased, exposure to ultraviolet radiation increased, which is consistent with the results of Ghasemzadeh et al.[14]

There was also a significant correlation between the amount of infrared radiation, and exposure duration and work experience so that as exposure to ultraviolet radiation increased, the amount of exposure also increased. The amount of ultraviolet and infrared radiation depends on the type of welding, so that the amount of ultraviolet and infrared radiation in the electric welding is greater than that in gas welding, which is consistent with the results of the study of Aliabadi et al.[12]However, the intensity of waves in electric welding with coated electrodes is higher than that in protective gas welding. In the welding with a coated electrode, the temperature of the arc is very high, which creates infrared waves, but in welding with protective gas, due to the cooling down of the weld by carbon dioxide, less infrared radiation is produced.[14]There was no significant difference in the amount of ultraviolet and infrared radiation with respect to the height (hand and eye area) and distance of measurement (10, 50 and 100 cm), which means that these distances are located in the near field, and no substantial decrease in the amount of radiation in this field is observed.

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Table 3. Number of welders with eye symptoms

Row	Eye problem	Number	Percentage
1	Eye irritation	4	5.70
2	Watering eyes	2	2.90
3	Eye irritation and pain	1	1.45
4	Watering eyes and eye pain	2	2.90
5	Watering eyes and eye irritation	4	5.70
6	Blurred vision and watering eyes	1	1.45
7	Eye irritation and the sensation of having sand in the eyes	2	2.90
8	Eye pain, irritation, and blurred vision	4	5.70
9	Watering eyes, eye irritation, and blurred vision	1	1.45
10	The sensation of having sand in the eyes, watering eyes, and eye irritation	10	14.50
11	The sensation of having sand in the eyes, eye pain and irritation	8	11.30
12	Watering eyes, eye pain, and irritation	4	5.70
13	The sensation of having sand in the eyes, eye irritation and blurred vision	1	1.45
14	The sensation of having sand in the eyes, watering eyes, eye irritation, and blurred vision	12	17.10
15	No symptom	12	17.10

Giahi et al., in a study to evaluate the exposure to infrared radiation, concluded that exposure to this radiation exceeded the limit, which is not consistent with the results of our study.[16] This inconsistency is also due to differences in the type of occupation studied. Regarding the average amount of exposure to ultraviolet and infrared radiation in welders with at least one eye problem compared to those with no eye problem, the results showed that the higher the ultraviolet radiation during welding, the more welders experienced eye problems, which is in agreement with the study of Zamanian et al.[17]

The limitations of this study are the lack of evaluation of the effectiveness of eye protection equipment, the amount of welding voltage and the type of electrode used, which can have an impact on the amount of infrared and ultraviolet radiation. In the end, it is recommended to reduce the duration of exposure of the welders or welders should do welding during the day intermittently, and use suitable personal protective equipment, especially a suitable welding mask, during welding. Besides, welders should receive the necessary training on the hazards of exposure to ultraviolet and infrared radiation.[18]

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