EXPLORING THE TOXICITY LEVELS OF CHROMIUM AMONG WELDERS

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Abstract

Introduction: Welders are at the risk of exposure to Chromium which is associated with adverse health effects.

Study objectives: To determine the prevalence of chromium toxicity among workers in welding industry, and to correlate the occupational exposure for chromium with respiratory morbidity symptoms.

Methodology:

Study design and setting: Cross-sectional experimental study design. The present study was conducted at Irbid Industrial City. A convenient sample of 51 participants was included in the study in addition to 61 references as a control group. Urine Chromium level was analyzed at Princess Haya Center for Biotechnology using Atomic Absorption Spectrometry.

Results: The mean concentration of Chromium 15.87 ug/dl with SD $\pm$ 14.52 ug/dl and 25.05 ug/dl with SD $\pm$ 14.60 ug/dl for control group and welders respectively. There was a significant relationship between chromium exposure among welders compared with control (p value 0.000).

Conclusion:

1- The present study showed that there is a significant exposure to Chromium among welders.

2- There is a significant correlation between Chromium and respiratory diseases as sensitivity.
3- Chromium was correlated significantly with possible high potential of certain environmental issues to have Chromium such as living close to factory, hazard wastes, organic solvents and gases.

Keywords: Toxicity chromium, welders

Introductio

An Overview of Industrial Use of Welding

Welding is considered the principal industrial process used for joining metals. It has been shown that 0.2 to 2 per cent of the total workforce is engaged in welding in industrialized countries. Furthermore, welding workers are exposed to fumes and gases which may be hazardous to their health (Stern, 1981; Australian Government Publishing Service Canberra, 1990).

Welders usually used mild steel in welding process, but welding of stainless steel and high performance alloyed steel is also widely practiced. It is probably that a large number of welders use the most common welding methods, manual metal arc (MMA) and metal active or inactive gas (MAG or MIG), are exposed to welding fumes at concentrations far exceeding the threshold limit values proposed by the National Institute of Security and Health (Stern et al., 1986).

Adverse health effects on welders

It has been recently shown that welding may have deleterious effects on the male reproductive system. By two case-control studies of infertile couples, it was found an increased risk of reduced semen quality (Rachootin and Olsen, 1983; Mortensen, 1988). Other studies showed associations between paternal exposure to welding and delayed conception and reduced fertility (Bonde, 1990; Bonde, in press). Other effects due to a long-term exposure of welders to welding fumes include various diseases of a respiratory system (Voitkevich, 1995; Sinczuk-Walczak, 2001). The airways are the main route by means of which dusts enter a human body. Pneumoconiosis may affect welders as early as after several years of work and is considerably more common in case of welders working in small or badly ventilated rooms rather than in case of those who work outdoors. Asthma and bronchitis incidenence rates are increased among welders. Other illnesses may occur simultaneously as diseases of nervous, cardiovascular or digestive systems (Voitkevich, 1995; Jolanta, 2009).

Other reports showed that several cases of acute poisoning resulting from heavy exposure to one or more welding fume or gas were documented (Australian Government Publishing Service Canberra, 1990).

The Involvement of Chromium in Welding

It has been reported that core and filler metals are usually made of alloy similar in chemical composition to the materials being welded. The most commonly used material is mild steel. Special steels usually have chromium, nickel, molybdenum, aluminum, cobalt, vanadium or tungsten. Chromium is the main constituent in stainless steel electrodes, up to 26%, while nickel (21%) while manganese content is about 14%. In high-chromium hard facing electrodes, the chromium content may contain up to 30 per cent chromium, present as chromium metal and chromium carbides (Australian Government Publishing Service Canberra, 1990).

Study Hypothesis

In the present study, it is proposed that welders have occupational risks due to exposure to welding fumes. These risks are proposed to be significantly correlated with years of exposure and way of practice. Both of knowledge and perception of welders for occupational risks are also thought to correlate significantly with occupational risks.

Study objectives

1- To determine the prevalence of chromium toxicity among workers in welding industry.
2- To correlate the occupational exposure for chromium with respiratory morbidity symptoms.

Methods and Subjects

Study Design

The study design for the present study is cross sectional. Cross sectional design is concerned with gathering data from all participants at the same time point interval.

Study Population

The present study targeted workers in welding in Irbid Industrial City. The present study was conducted for determination of chromium levels in urine. The target population is all welding workers who work in the welding shops in Jordan. A convenient sample of 80 welding workers were selected from those available in Industrial City welding shops in Irbid City. All workers in welding shops who were working in the selected setting were included in the study.

Data Collection

The groups involved in this study consisted of 80 welders in addition to 80 references as controls who are not welders. All of them were from the Irbid City. All of them were males.

All the subjects were willing to participate in the study, and signed a consent form of the protocol of the study and it was explained to each one of them by researcher that the sample they will give will be used for research purposes. The consent form had been approved and certified by the Human Researcher committee at Jordan University of Science and Technology.

Samples Collection

Questionnaires were filled by the participants. In addition to that, the researcher collected urine samples from welders and the control group.

Questionnaire

The first set of questions in the questionnaire determine the demographic data of the participants under this study includes age, gender, smoking habits, type and place of occupation, and duration of employment. The second set of questions included working type, job type, use of personal protective equipment such as mask, gloves and lab-coat, diseases such as sensitivity, urinary tract infection, the perception of participants for occupational dangers associated with their job, and the frequency of welding times.

Urine Samples

The participants were provided with urine containers and asked to give urine samples. After that, sample were kept frozen in deep refrigerator at -70 C until the time of analysis.

Sample Analysis for Heavy Metals

The concentrations of chromium were analyzed by atomic absorption spectrophotometer (AAS) which allow for the measurement of a wide range of concentrations of metals in biological samples. The AAS consist of a Flam Atomic Absorption Spectrometry (F-AAS) (Shimadzu, AA-6300, Tokyo, JAPAN) fully equipped for flame (air acetylene), and a Graphite furnace atomization (GFA-AAS) (Shimadzu, EX7, Tokyo, JAPAN). The samples were analyzed using the spectrophotometer placed at the Princess Haya for biotechnology.

Statistical Analysis

The data obtained from analysis the urine of the subjects investigated in this study regarding the concentration of the heavy metals and the

associated factors demographically and environment of work were analyzed statistically by multivariable analysis and Mann–Whitney test using statistical package for the social sciences SPSS (version 16, SPSS, an IBM Company, Chicago, USA). P value of ≤0.05 was considered statistically significant in the result presented of the study.

Results

Demographic Characteristics of participants

The data presented in table 1, showed that about 65% of study participants and about 48% of participants were married. The study included 51 welders and 61 references (controls).

Table 1: Demographic Characteristics of participants

VARIABLE	STUDY GROUP		CONTROL GROUP	
	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)
Marital status:				
-married	**33**	**64.70**	**30**	**48.38**
-single	**10**	**19.60**	**10**	**16.12**
Missing	**8**	**15.86**	**22**	**35.48**
Job:				
-Welder	**51**	**100**	**61**	**100**
-Non welder	**0.0**	**0.00**	**0.00**	**0.00**

Use of Protection Tools among study participants

The results indicated the use of hearing protective tools among study and control groups to be closed to each other (study group, 7.84%; control group 8.20). Protective coats were also used with similar ratios (study group 45.10%, control group 42.62%). Study group reported more using gloves (53%) than control group (34.43%). Study group expressed more usage of protective glasses (80.4%) compared with control group (8.20). protective shoes were shown to be more used by study group (58.82%) compared with control group (14.75%). Head cap was also expresses to be more used by study group (37.3%) compared with control group (11.47%). Welding eye glasses were also used more by study group (86.3%), while only 1.63% of control group expressed their use. Slightly less than the half of study group expressed the use of face mask (45.1%) compared with non use (0%) among control group.

Table 2: The use of protective tools during working

Variable	Study group		Control group	
	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)
Hearing tools:				
-Yes	**4**	**7.84**	**5**	**8.20**
-No	**47**	**92.19**	**56**	**91.80**
Protective coat:				
-Yes	**23**	**45.10**	**26**	**42.62**
-No	**28**	**54.9**	**35**	**57.38**
Gloves:				
-Yes	**27**	**52.9**	**21**	**34.43**
-NO	**24**	**47.1**	**40**	**65.57**
Glasses:				
-Yes	**41**	**80.4**	**5**	**8.20**
-No	**10**	**19.6**	**56**	**91.80**
Shoes (protective):				
-Yes	**30**	**58.82**	**9**	**14.75**
-No	**21**	**41.18**	**52**	**85.25**
Head cap:				
-Yes	**19**	**37.3**	**7**	**11.47**
-No	**32**	**62.7**	**56**	**88.53**
Welding glass:				
-Yes	**44**	**86.3**	**1**	**1.63**
-No	**7**	**13.7**	**60**	**98.37**
Face mask:				
-Yes	**23**	**45.10**	**0.0**	**0.00**
-No	**28**	**54.90**	**61**	**100**

The Exposure to Work Related Risks

Welders are exposed to certain risks during their work including gases which were more expressed by study group (78.4%) compared with control group (32.78%). Welders are more exposed to metal gases (92.2%) compared to control groups (29.5%). Noise contamination was reported by 52.94% of welders compared by 13.11% of control group. Thermal stress was experienced by 78.43% of welders compared to 8.20% of control group. About 59% of welders reported living closed to factory compared about 34% of control group. Smoking in control group was more expressed (31.15%) compared to welders (27.46%).

Table 3: Work Related Risk Factors

Variable	Study group		Control group	
	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)
Gases:				
-Yes	**40**	**78.4**	**20**	**32.78**
-No	**11**	**21.6**	**41**	**67.22**
Metal gases:				
-Yes	**47**	**92.2**	**18**	**29.50**
-No	**4**	**7.8**	**43**	**70.50**
Noise contamination:				
-Yes	**27**	52.94	**8**	**13.11**
-NO	**24**	47.06	**53**	**86.89**
Cold/ heat:				
-Yes	**40**	**78.43**	**5**	**8.20**
-No	**11**	**21.57**	**56**	**91.80**
Living closed to factory:				
-Yes	**30**	**58.82**	**21**	**34.43**
-No	**21**	**41.18**	**40**	**65.57**
Smoking:				
-Yes	**14**	**27.46**	**19**	**31.15**
-No	**37**	72.54	**42**	**68.85**

Disease Shared among Study Participants

About 6% of welders experienced epilepsy while no cases were reported by control group. Diabetes was more experienced by control group (29.5%) compared with about 14% of welders who reported having diabetes. Sensitivity was also reported welders (52.94%) compared to 13.11% of control group. Asthma was also experienced by 43.1% of welders compared to 16.39% of control group (table 4).

Table 4: Diseases experienced by study participants

DISEASE	STUDY GROUP		CONTROL GROUP	
	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)
Epilepsy:				
-Yes	**3**	**5.88**	**0.0**	**00**
-No	**48**	**94.12**	**61**	**100**
Diabetes :				
-Yes	**7**	**13.7**	**18**	**29.50**
-No	**44**	**39.3**	**43**	**70.50**
Sensitivity:				
-Yes	**27**	**52.94**	**12**	**13.11**
-NO	**24**	**47.06**	**39**	**86.89**
Asthma:				
-Yes	**22**	**43.1**	**10**	**16.39**
-No	**29**	**56.90**	**51**	**83.61**

The Relationship between Chromium Level and Study Variables

Chi square cross tabulation was used to explore the statistical relationships between chromium level in welders and study variable. The results presented in table 5 showed that welder's chromium was correlated significantly with sensitivity (p value 0.03), smoking (p value 0.015), living close to factory (p value 0.003), hazard wastes (p value 0.024), stress (p value 0.00), organic solvents (p value 0.00), gases (p value 0.00), face mask (p value 0.002), and eye glasses (p value 0.032).

Table 5: The relationship between chromium level and study variables

CHROMIUM	VARIABLE	P VALUE
	Epilepsy	**0.117**
	Diabetes	**0.477**
	Asthma	**0.436**
	Sensitivity	**0.03**
	Bronchitis	**0.311**
	Hepatitis	**0.500**
	Smoking	**0.015**
	Living close to factory	**0.003**
	Hazard wastes	**0.024**
	Stress	**0.00**
	Organic solvents	**0.00**
	Gases	**0.00**
	Face mask	**0.002**
	Eye glass	**0.032**

The Relationship between Chromium Level and Other Study Variables

As shown in table 6, T test was used to explore the relationship between chromium level and other variables. The results showed that there is a significant correlation between weekly working hours and chromium level (p value 0.000). Another correlation was scored between previous smoking packets per day and Chromium level (p value 0.006). Smoking packets per day was also correlated significantly with Chromium level (p value 0.001). Smoking years were not correlated significantly Chromium level (p value 0.232).

Table 6: The Relationship between Chromium and Other Study Variables

PAIR	MEAN	SD	P VALUE
Weekly working hours	51.46	14.64	0.000
Chromium	19.84	13.77	
Previous smoking packets per day	1.36	0.49	0.006
Chromium	14.48	14.92	
Smoking packets per day	1.43	0.573	0.001
Chromium	14.050	12.54	
Smoking years	9.73	6.40	0.232
Chromium	13.52	14.88	

Discussion

The present study investigated the industrial effects of welding industry on workers through exploring the Chromium level in urine sample of welders.

Taken together, the present study has to satisfy the following objectives: to determine the prevalence of chromium toxicity among workers in welding industry, and to correlate the occupational exposure for chromium with respiratory morbidity symptoms.

The data of the present study showed that the mean chromium levels were 15.87 ug/dl with SD $\pm$ 14.52 ug/dl and 25.05 ug/dl with SD $\pm$ 14.60 ug/dl for control group and welders respectively. The results showed a significant correlation between exposure level between welder group and control group (p value 0.000). The findings of the present study are in line with other studies in which it was reported that welders are exposed to Chromium and subjected to adverse health effects. On this trend of research, several researchers such as (Pritchard, 2001;Waalkes, 2000; Carlisle, 2000) reported that Cr VI exposure leads to various cellular interferences such as cell cycle arrest, neoplastic transformation or apoptosis induction depending on cell type, concentration of the metal and time of exposure.

The results of the present study showed that Chromium level is correlated significantly with sensitivity (p value 0.03). These findings agree with other reported results in literature in which it was shown that effects due to a long-term exposure of welders to welding fumes include various diseases of a respiratory system (Sinczuk-Walczak, 2001; Voitkevich, 1995).

The data of our results showed a significant correlation between chromium level and smoking (p value 0.015). These findings agree with other results in which it was recommended that ongoing workplace measures to reduce exposure to metal fumes and promote smoking cessation should be reinforced (Alexander Wong, 2010).

The results also showed significant correlation with living close to factory (p value 0.003). Other studies showed Chromium has various concentrations in environment. Its concentrations in soil range between 1 and 3000 mg/kg, in sea water 5 to 800 µg/liter, and in rivers and lakes 26 µg/liter to 5.2 mg/liter (Kotaś,; Stasicka, 2000).

In the context of this view, it can be understood the significant correlations between Chromium and hazard wastes, organic solvents, and gases.

Conclusion

The present study showed a significant exposure to Chromium among welders. Significant correlation between Chromium and respiratory diseases as sensitivity was shown. Chromium was correlated significantly with

possible high potential of certain environmental issues to have Chromium such as living close to factory, hazard wastes, organic solvents and gases.

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