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ORIGINAL ARTICLE

Effects of occupational exposure on the hematologic parameters among welders

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ABSTRACT

Introduction: The effect of prolonged exposure to welding fumes on blood levels remains an unresolved question. In our study, we aimed to determine the effects of metal fume exposure on various blood parameters in welders.

Materials and Methods: The study was cross-sectional. It included all male welding workers admitted to a health institution, a reference hospital for occupational diseases, for 2021. It was conducted with 254 individuals. The variables examined included age, duration of employment, smoking habit, body mass index, hemoglobin levels, erythrocyte, leukocyte and platelet counts, aspartate aminotransferase, alanine aminotransferase, free prostate-specific antigen, creatinine and manganese levels, and erythrocyte sedimentation rates.

Results: In our study, 40.6% of the welders were between 21-30 years old. 65.7% of the participants have been welding for more than five years. According to body-mass index values, 44.1% of the participants were pre-obese, and 16.9% were obese. 63.8% of the participants were smokers. In 35.8% of participants, hyperglycemia was present, and polycythemia was present in 27.2%. When blood parameters were analyzed, fasting blood glucose, aspartate transaminase, alanine transaminase, and sedimentation rate were lower in those who worked less than five years than those who worked five years or more. The difference was statistically significant. In blood test results, leukocyte, glucose, aspartate transaminase, alanine transaminase, and sedimentation rate values in welders were correlated with total working time.

Conclusion: Welders in our study had a high prevalence of smoking, overweight, and obesity. Working time is correlated with liver enzyme levels and fasting blood glucose values. For healthier workers, employers should fulfill their responsibilities for occupational health and safety.

Keywords: Welding, biological monitoring, occupational exposure, health surveillance

INTRODUCTION

Welding is a widely used industrial process in which high temperatures join metals, producing potentially hazardous metal fumes [1]. Approximately 11 million people worldwide work as welders, and 110 million are exposed to welding fumes [2]. The composition of welding fumes, classified as group 1 carcinogen by the International Agency for Research on Cancer, varies depending on the type of welding performed. Although it is affected by many factors such as welding method, electrode type, filler metal, fluxes, protective gases, and base metals, it always contains various metal particles [3].

Metal fume exposure in welders is associated with many health problems. Welders face a heightened risk of chronic exposure, particularly to airborne manganese found in welding materials. However, the impact of prolonged exposure to manganese or welding fumes on blood levels remains an unresolved question [4]. Studies have shown that exposure to metal fumes can lead to hyperglycemia, may be associated with an increase in the prevalence of diabetes, and that occupations associated with high levels of metal exposure, such as welding, are at risk for diabetes [5-7]. Obesity is a common risk factor for diabetes. Since reducing body weight will lead to the prevention, control, and regression of diabetes, it is essential to examine body mass indexes in the health surveillance of workers [8]. Since serum creatinine levels may be associated with an increased risk of diabetes, it is recommended that blood creatinine levels should also be examined in screenings to identify those at high risk of diabetes [9]. A positive correlation was between creatinine level and working time, aspartate/alanine aminotransferase levels, and age. It is also necessary to check liver enzyme levels and evaluate renal function during periodic control examinations of workers exposed to metal fumes [10]. Hepatocytes are damaged in people occupationally exposed to heavy metal fumes; therefore, aspartate aminotransferase, alanine aminotransferase, and gamma-glutamyl transferase levels are increased in the bloodstream. It is also thought that liver functions deteriorate, and non-alcoholic fatty liver disease develops in these individuals due to gene interactions [11].

Considering all these, it is understood that the welding profession involves significant risks regarding employee health. Health surveillance of welders is critical to reveal these risks in all aspects and take appropriate measures regarding worker health. Welders are a suitable group for biological monitoring to measure occupational exposure tendency and to examine dose-response relationships. In this study, we aimed to determine the effects of metal fumes on various hematological parameters in welders and to reveal the potential health effects of occupational exposure.

MATERIALS and METHODS

The study was cross-sectional. It was conducted in Ankara Occupational and Environmental Diseases Hospital, a reference hospital for occupational diseases. The study population included male welding workers between the ages of 21 and 50 who applied to the hospital for periodic health examinations during 2021, had been working for at least one year, spent at least eight hours a day in welding work, and were between the ages of 21 and 50. There were no female welding workers among the applicants. As it affects the elimination of heavy metals; those who used any medication or herbal supplements such as vitamins, N-acetylcysteine, and lipoic acid, those with a history of alcohol consumption, those with chronic diseases, and those who had recently undergone surgery were excluded. Sample selection was not made, and all workers who met the inclusion criteria were in the study, which was conducted with 254 people.

Among the parameters examined in the study, data on age, employment duration, and smoking habits were obtained from the periodic examination forms. Height and body weight were measured during the examination, and body mass index was calculated. The results of routine complete blood count and serum biochemistry tests were evaluated. Blood parameters examined included hemoglobin levels, erythrocyte, leukocyte, and platelet counts, aspartate aminotransferase (AST), alanine aminotransferase (ALT), free prostate-specific antigen (PSA), creatinine and manganese levels, and erythrocyte sedimentation rates. Blood samples were collected in purple-capped EDTA tubes, and the tube was gently inverted and mixed 5-6 times as soon as the blood was collected to

avoid clot formation. Serum samples were collected in 10 ml red-capped 16x100 mm tubes without gel, centrifuged at 1500 x g for 10 min, and separated and stored until the analysis time. Inductively coupled plasma-mass spectrometry method was used to analyze the manganese samples. The Ethics Committee of Gazi University ethically approved the study, and informed consent was obtained from all participants.

Statistical analyses were performed using the Statistical Package for Social Science (SPSS) for Windows 25.0. In the descriptive statistics section, categorical variables were presented as numbers and percentages, and continuous variables as mean ± standard deviation and median (minimum-maximum value). The data obtained were analyzed for normal distribution using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data conforming to normal distribution were evaluated with the Student's t-test. In the case of non-normally distributed data, the Mann-Whitney U test was applied to determine the difference between the groups. In addition, Spearman and Pearson correlation tests were used to investigate the relationship between blood parameters and study duration. $p<0.05$ was considered statistically significant.

RESULTS

In our study, 40.6% of the welders were between 21 and 30, 28.7% were between 31 and 40, and 30.7% were between 41 and 50. 34.3% of the participants have been welding for less than five years, 29.8% for 5-9 years, 15.0% for 10-19 years, and 20.9% for 20 years or more. According to body-mass index values, 1.6% of the participants were underweight, 37.4% were average weight, 44.1% were pre-obese, and 16.9% were obese. 63.8% of the participants were smokers (Table 1). Hyperglycemia was present in 35.8%, polycythemia in 27.2%, thrombocytosis in 12.6%, elevated sedimentation in 11.4%, elevated alanine aminotransferase in 10.6%, leukocytosis in 7.1%, elevated aspartate aminotransferase in 5.9% and elevated free prostate-specific antigen in 5.9% (Table 2). When the blood parameters of the participants were analyzed, fasting blood glucose was 95.7±11.4, aspartate transaminase 19.6±6.6, alanine transaminase 27.2±16.1 and sedimentation rate 7.5±5.5 in those who had worked less than five years. In those who worked five years or more, these values were 100.4±25.5, 23.0±8.6, 31.1±19.2 and 9.1±5.4, respectively. The difference was statistically significant ($p<0.05$). No significant correlation existed between hemoglobin, platelet, manganese, and creatinine values in blood tests and working for five years or more (Table 3). In the blood test results, leukocyte, glucose, aspartate transaminase, alanine transaminase, and sedimentation rate values were correlated with total working time (Table 4).

DISCUSSION

In our cross-sectional study of welders admitted to a hospital where many occupational diseases in Turkey are detected, the participants' health examination results were evaluated, and the

Table 1. Sociodemographic characteristics of participants, Türkiye, 2022

	(n)	(%)
Age (n=254)		
21-30 years old	103	40.6
31-40 years old	73	28.7
41-50 years old	78	30.7
Working time (n=254)		
Less than 5 years	87	34.3
5-9 years	76	29.8
10-19 years	38	15.0
More than 20 years	53	20.9
Body-mass index (n=254)		
<18,5 kg/m2	4	1.6
18,5-24,9 kg/m2	95	37.4
25,0-29,9 kg/m2	112	44.1
>30,0 kg/m2	43	16.9
Smoking (n=254)		
Yes	162	63.8
No	92	36.2

Table 2. Laboratory characteristics of participants, Türkiye, 2022

	(n)	(%)
Hyperglycemia	91	35.8
Polycythemia	69	27.2
Thrombocytosis	32	12.6
Elevated ESR	29	11.4
Elevated ALT	27	10.6
Leukocytosis	18	7.1
Elevated AST	15	5.9
Elevated fPSA	15	5.9

Table 3. Blood test results according to participants' working time, Türkiye, 2022

	< 5 years (n=87)	≥5 years (n=167)
Hemoglobin (n=254) **		
Mean±SD	16.3±1.0	16.2±0.9
Median	16.3	16.3
Range (min-max)	13.6-18.5	12.0-18.8
p=0.451		
Leukocytes (n=254) *		
Mean±SD	7.4±1.6	8.0±2.2
Median	7.3	7.6
Range (min-max)	4.6-11.5	3.7-18.1
p=0.091		
Platelets (n=254) **		
Mean±SD	244.7±51.5	244.9±58.0
Median	247	236
Range (min-max)	145-400	145-400
p=0.987		
Glucose (n=254) *		
Mean±SD	95.7±11.4	100.4±25.5
Median	95	97
Range (min-max)	69-161	56-341
p=0.042		
Aspartate transaminase (n=254) *		
Mean±SD	19.6±6.6	23.0±8.6
Median	18	21
Range (min-max)	10-43	12-78
p=0.015		
Alanine transaminase (n=254) *		
Mean±SD	27.2±16.1	31.1±19.2
Median	22	26
Range (min-max)	9-89	9-155
p<0.001		
Sedimentation rate (n=254) *		
Mean±SD	7.5±5.5	9.1±5.4
Median	6	8
Range (min-max)	1-25	3-36
p=0.001		
Manganese (n=254) *		
Mean±SD	11.9±4.2	11.3±3.5
Median	11.6	11,1
Range (min-max)	4.8-23.0	4.7-24.0
p=0.353		
Creatinine (n=254) **		
Mean±SD	0.84±0.10	0.84±0.09
Median	0.84	0.83
Range (min-max)	0.6-1.1	0.6-1.1
p=0.798		

asdf * Independent samples t-test, **Mann-Whtitney U test

Table 4. Correlation of blood parameters with working time

	r	p
Hemoglobin	-0.032	0.614
Leukocytes	0.127	**0.043**
Platelets	-0.002	0.969
Glucose	0.202	**0.001**
Aspartate transaminase	0.176	**0.005**
Alanine transaminase	0.147	**0.019**
Sedimentation rate	0.205	**0.001**
Manganese	-0.077	0.219
Creatinine	-0.047	0.459

relationship between occupational exposure and blood parameters was examined. In addition, some chronic disease risk factors that may negatively affect the general health status of workers were also discussed. Our findings will be helpful in terms of revealing the effects of welding fumes on workers' health.

Approximately three-fifths of the welders in our study were smokers. 22.3% of the world population (36.7% of men) use tobacco products, and approximately 80% of the 1.3 billion users are in low- and middle-income countries [12]. In Turkey, the prevalence of smoking in men aged 15 years and older is 41.3% [13]. In studies conducted in Iran and Taiwan, the prevalence of smoking among welders is approximately one-third. Simultaneous cigarette and welding fumes exposure was associated with decreased pulmonary function [14,15]. In another study conducted in Turkey, welding increased the risk of chronic bronchitis by 2.8 times and smoking by 3.2 times [16]. The prevalence of smoking among welders in our study was higher than the population average. Smoking habits of certain occupational groups may be more common. Social interaction among welders or workplace culture may encourage smoking. Welders who are under stress due to their jobs may adopt smoking as a relaxation method.

In light of our findings, 44.1% of the participants were pre-obese, and 16.9% were obese according to their body mass index. The mean body mass index of the participants was 26.4. In European Union countries, the prevalence of pre-obesity in men was 43.9%, and the prevalence of obesity was 16.3% [17]. In Turkey, 39.7% of men aged 15 years and older are pre-obese, and 17.3% are obese [18]. In a study conducted in China to investigate the health

status of welders, 52.6% of welders were pre-obese or obese [19]. In a study conducted on welders in Canada, the prevalence of pre-obesity and obesity was 61% [20]. In Taiwan, welders' average body mass index was 25.2 [21]. In the United States, pre-obesity prevalence among workers was 36.1%, obesity was 22.0%, and the mean body mass index was 26.2. In advanced clerical and service sector workers, these prevalences were 50.4% and 27.3%, respectively, with an average BMI of 28.3 [22]. According to the average body mass index in the Netherlands, those working in the transportation sector are in the first place, with 25.2. Those working in the metal industry have an average body mass index of 24.7. The prevalence of overweight and obesity in this sector is 36.1% and 6.0%, respectively [23]. The prevalence of pre-obesity and obesity in welders in our study is similar to the population average and other studies conducted in the same occupational group. Working in a physically demanding job, with irregular or long working hours, may increase the tendency to gain weight. Lack of physical activity opportunities in some occupations may lead to obesity. Limited healthy eating options and irregular eating habits at work are also risky. We think that the prevalence of pre-obesity and obesity in welders is alarming in terms of worker health.

According to the results of the complete blood count performed in our study, leukocytosis was in 7% of the participants, and a weak correlation was between the total working time of the participants and the leukocyte count. In a study conducted in the United States of America, a significant increase in total leukocyte count was found in non-smoking welders immediately after exposure to welding fumes. Acute systemic inflammatory reactions were observed hours after welding fume exposure [24]. In a case-control study conducted in Ghana, total leukocyte count did not show a significant difference between welders and non-welders [25]. In our study, high smoking frequency may lead to leukocytosis. Leukocytosis may be natural, but prolonged or persistent high white blood cell levels may indicate health problems. More comprehensive studies are needed to understand the effects of occupational exposure on leukocyte levels.

Our study found that liver enzyme levels were higher in welders who had worked for five years or more compared to those who had worked for less than five years, and these levels were correlated with total working time. In a similar study conducted in Turkey investigating the effect of manganese exposure on the erythropoietic system, AST and ALT levels were higher in welding workers than in-office workers [26]. In a study conducted on healthy workers in a ferromanganese refinery in China, AST and ALT levels were higher in welding and production workshop workers than in other worker groups, such as drivers and cooks [27]. A study conducted in Poland found that serum AST and ALT levels were significantly different in foundry workers compared with the control group [28]. In Iran, AST and ALT levels were significantly higher in miners than in the control group [29]. Increased concentrations of AST and ALT enzymes have been reported in mice exposed to welding fumes [30]. Although the type and solubility level of heavy metals to which welders are exposed vary depending on the type of welding process and welding electrode, an increase in AST and ALT levels may be observed in all workers exposed to multiple heavy metals due to the development of liver damage. It may not only be due to the welding work of the workers but may also indicate other health problems. Nevertheless, based on the findings in the literature, welders are a risky group in terms of liver health.

Our study found that fasting blood glucose levels were higher in welders who worked for five years or more than those who worked for less than five years, and these levels were correlated with total working time. A study conducted on shipyard workers in Taiwan found that heavy metal exposure disrupted glucose homeostasis, and welders had higher fasting blood glucose levels than administrative workers [31]. A study investigating the potential association of metal levels with diabetes risk in workers in complex coal furnaces in China showed that high levels of many metals measured in urine were associated with hyperglycemia and diabetes risk [32]. Similar results were also in another study evaluating toxic metals in biological samples of diabetic patients [33]. In a study investigating the relationship between metal exposure and cardiometabolic risk factors in young men of African descent living in different countries, it was reported that insulin resistance and oxidative stress may be induced by metal exposure in breathing air and may lead to abnormal glucose metabolism

and increase the risk of developing diabetes [34]. As seen, researchs shows that metal exposure can trigger diabetes risk factors and effect glucose homeostasis. Metals, which cumulatively accumulate more in the body as the duration of work increases, may increase inflammation at the cellular level due to their toxic effects and lead to hyperglycemia over time.

CONCLUSION

The majority of the welders in our study were found to be smokers. The prevalence of overweight and obesity among the participants was considerable. A correlation was found between working time liver enzyme levels and fasting blood glucose values. As in all occupational groups, health surveillance, workplace environment measurements, and organizational arrangements are essential for welders. Periodic health examinations are necessary to assess health problems accurately. These examinations can help diagnose respiratory problems caused by smoking and welding fumes. Weight monitoring can help identify employees at risk of obesity. Parameters such as liver enzyme levels and blood glucose should also be checked. Early detection can help end exposure and start treatment as soon as possible. Welders should be trained about the occupational health and safety risks they face. They should be made aware that they should not smoke. Workers should be given accurate nutrition information and encouraged to develop healthy behaviors. Support can be provided to employees through smoking cessation programs. Providing exercise in the workplace can help prevent obesity or promote weight loss. These activities can also have positive effects on metabolic health. Appropriate measures should be taken to make workplace environments healthier and safer. In this context, measures to reduce exposure should be prioritized. The effectiveness of ventilation systems is vital in determining the distribution and levels of harmful substances, such as welding fumes, in the work environment. It is essential to install better ventilation systems or use personal protective equipment. Regulating working hours and exposure time can help workers rest and reduce their exposure. All this will be possible if employers fulfill their responsibilities and obligations concerning occupational health and safety.

Author contribution

Study conception and design: VM, RA and PÇ; data collection: PÇ; analysis and interpretation of results: VM and FB; draft manuscript preparation: VM, RA and İM. All authors reviewed the results and approved the final version of the manuscript.

Ethical approval

The study was approved by the Gazi University Ethics Committee (Protocol no. 2023-1306).

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Conflict of interest

The authors declare that there is no conflict of interest.

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