Research Article

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Investigating the Effects of Occupational Exposure to Chromium and Vanadium on Diabetes

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Abstract

Introduction: *Diabetes is one of the most important and complicated diseases that requires serious follow-up and control. Non-occupational and occupational risk factors are known but need more investigation. With regard to the limited research on this subject, the goal of this study is to determine the effects of occupational exposure to Chromium and Vanadium on diabetes.*

Methods: *This case-control study was performed from 1997-98 and 100 carpenters and mechanics living in Khomein (50 people in each group) were examined in an unlikely and easy way. The information on the studied units was recorded using a questionnaire. in addition to the questions mentioned in the questionnaire, blood pressure, height, weight, and waist circumference were measured in one turn. HbA1C, BS2hpp, and FBS tests were also requested for each subject and finally, the data were analyzed by Chi-square test, Mann-Whitney, Kolmogorov-Smirnov test, and independent t-test.*

Findings: *In the present study, the comparison of fasting blood sugar levels of mechanics and carpenters did not show a statistically significant difference according to the mean numbers and standard deviations, except for the variable duration of employment per day (p = 0.003(. Findings suggest that there is no significant difference between the two groups in the incidence or non-incidence of diabetes (p=0.065).*

Discussion and conclusion: *The results show that job confrontation with chromium and vanadium did not have a statistically significant difference in the development of diabetes. However, annual examinations and tests are recommended to identify patients early and prevent disorders.*

Keywords: Chromium, Vanadium, Occupational Exposure, Diabetes

Introduction

Diabetes mellitus is a prevalent chronic metabolic condition resulting from intricate interactions between genetic and environmental factors and is characterized by above-normal elevations in blood glucose concentration [1, 2]. Uncontrolled diabetes leads to various complications, most of which are fatal or at least diminish the quality of life perceived by diabetic patients and their families [3].

A deficiency of trace elements such as chromium and vanadium causes increased insulin resistance. Thus, modifying the essential trace element levels, particularly chromium and vanadium, plays a significant role in diabetes mellitus. However, their impacts on metabolic syndrome incidence are understudied [4]. Chromium is an essential micronutrient with antioxidant properties and multiple functions in humans and is crucial for the normal homeostasis of glucose and fat [5, 6]. Trivalent chromium is a component of the glucose tolerance factor complex, and its deficiency may lead to reversible insulin resistance and diabetes [4, 5]. Vanadium is another element contributing to metabolic syndrome and diabetes [4]. Vanadium can induce its blood glucose-lowering effects by enhancing the sensitivity of insulin receptors in bodily tissues and, if the time is sufficient, exert its regenerative effects on the pancreas [7]. It is now believed that a synergistic effect exists between these elements in terms of their activities, meaning that vanadium and chromium are more effective together than alone [4]. Chromium-vanadium alloys have wide applications, such as scratch-proof metals, surgical instruments, and tools, and manufacturing various wrenches and equipment [8, 9]. Due to their high solubility in fat, the organic metal compounds can be easily absorbed via the skin [9]. Thus, the occupational exposure to these alloys and exposure duration, for instance, in workers employed in technical jobs, including automobile mechanics, can be associated with skin absorption of chromium and vanadium and consequently the reduced risk of diabetes [9].

Despite the identification of diabetes risk factors in recent decades, its associated occupational risk factors remain to be fully understood. Excess weight, poor diet, family history, smoking, stress, and comorbidities, such as dyslipidemia, account for non-occupational risk factors of diabetes. The suggested occupational risk factors include the type of job, occupational exposures, such as carbon disulfide, working shifts, and work stress [10, 11]. Some studies have established the impact of occupational factors on the incidence and exacerbation of chronic conditions, particularly diabetes and their resulting disability [12].

The present study aims to evaluate the impact of occupational exposure to chromium and vanadium on diabetes development. The results may be helpful in designing a method to enhance chromium and vanadium absorption, along with physical activity, to prevent diabetes incidence, progress, and complications.

Materials and Methods

The present case-control study was conducted from 2018 to 2019 on 100 carpenters and mechanics living in Khomein city (n=50 per group). After completing the informed consent form, the participants entered the study using non-random convenience sampling. The research received approval from the ethics committee of the Khomein University of Medical Sciences under the ethical code of IR.KHOMEIN.REC.1397.004.

Provided that the fasting blood sugar (FBS) drop was equal to 23.5% and 1.5% in the two groups [10], respectively, the minimum sample size required for the study was determined to be 42 per group at a power of 90%, and the first-type error of 5%. With an extra eight subjects added per group, a total of 100 people were recruited for this study.

$$n = \frac{2(\overline{p})(1-\overline{p})(Z_\beta + Z_{\alpha/2})^2}{(p_1 - p_2)^2}$$

The inclusion criteria for the study were a minimum of 5 years of work experience, and the exclusion criteria for both groups included not having diabetes and cardiovascular diseases.

Data were collected using a checklist that involved questions regarding demographic information, diabetes history, family history of diabetes, daily work duration, physical activity pattern (daily mobility), job experience, history of substance use, history of thyroid disorder, dyslipidemia, hypertension and liver disease, fat, salt and sugar consumption, medications, environmental factors, and daily sleep. A single interviewer completed the designed questionnaire. In addition to the questions included in the checklist, each patient's blood pressure, height, weight, and waist circumference were measured once. All participants received explanations regarding the research objective and the possible unwanted side effects. For each studied unit, blood glucose tests, including FBS, BS2hpp, and HbA¬1C, were ordered once in all patients. A 4 cc blood sample was taken from each patient by a trained nurse and submitted to the laboratory of Imam Khomeini Hospital of Khomein city for necessary examinations. During the study, all information was obtained from the studied units of the two groups. The collected data were analyzed and compared between the two groups using the SPSS-16 software. Descriptive and inferential statistical tests, including chi-square, Mann–Whitney U, Kolmogorov-Smirnov, and independent t-test, were applied in this study.

Findings

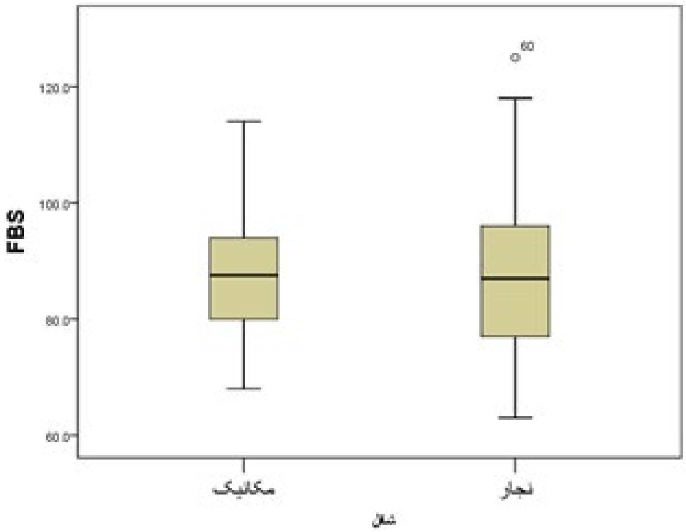
For data analysis in this study, the normality of numerical data distribution was initially checked using the one-sample Kolmogorov-Smirnov test. As shown in Table 1, the test results for numerical variables indicate that only the FBS variable follows a normal distribution, and other variables of patients are not normally distributed. Thus, non-parametric analysis methods were utilized to deal with the non-normal variables in analytical tests.

Table 1: The results of the Kolmogorov-Smirnov test to assess the numerical data distribution.

	Age (years)	Systolic blood pressure (mm Hg)	Diastolic blood pressure (mm Hg)	Weight (Kg)	Height (cm)	Work experience	Daily work hours	Fasting blood sugar	Blood sugar	HbA1c
Number	100	100	100	100	100	100	100	100	100	100
Mean	48.26	114.10	73.65	75.13	174.27	24.93	7.53	87.330	121.540	5.012
Standard deviation	9.202	14.640	11.889	11.423	9.716	11.047	1.845	11.8407	14.9561	0.6102
Asymp. Sig. (two-tailed)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.002

Comparison of mean FBS level between the auto mechanic and carpenter groups

A comparison of FBS levels between mechanics and carpenters using the t-test of two independent samples does not show any statistically significant difference (p=0.795). Plot 1 compares the mean and standard deviation of FBS levels in the two groups presented in Table 2.



Plot 1: A comparison of FBS levels' mean and standard deviation between auto mechanics and carpenters.

Table 2: A comparison of FBS levels by occupation type using the t-test of two independent samples.

	Occupation	Number	Mean	Standard deviation	p-value
FBS	Mechanic	50	87.020	10.7807	0.795
	Carpenter	50	87.640	12.9169	

Table 3 compares the detailed statistics of variables with non-normal distributions. Given the mean and standard deviation values in this table, the Mann-Whitney U test found no significant difference between the two groups for any of the reported variables except for the daily work duration (hour) (p=0.003).

Table 3. Frequency distribution of detailed statistics of non-normally distributed variables by occupation.

Statistics of variables with non-normal distribution				
	Occupation	Number	Mean	Standard deviation
Age (years)	Auto mechanic	50	47.12	8.465
	Carpenter	50	49.40	9.837
Weight (Kg)	Auto mechanic	50	74.80	9.553
	Carpenter	50	75.46	13.120
Systolic blood pressure (mm Hg)	Auto mechanic	50	111.80	12.768
	Carpenter	50	116.40	16.100
Diastolic blood pressure (mm Hg)	Auto mechanic	50	72.60	13.372
	Carpenter	50	74.70	10.223
Height (cm)	Auto mechanic	50	174.96	5.824
	Carpenter	50	173.58	12.484
Job experience	Auto mechanic	50	23.58	9.333
	Carpenter	50	26.28	12.480
Daily work duration (hour)	Auto mechanic	50	8.04	1.428
	Carpenter	50	7.02	2.075
Blood glucose (mg/dl)	Auto mechanic	50	118.240	9.5523
	Carpenter	50	124.840	18.3974
Percentage of HbA1c	Auto mechanic	50	5.010	0.5768
	Carpenter	50	5.014	0.6478

An analysis by chi-square test revealed no significant difference between the two groups regarding education level (p=0.470), marital status (p=0.646), residence location (p=0.401), and economic status (p=0.337). Concerning education level, 2% of carpenters were illiterate, 40% were elementary school graduates, 32% were middle school graduates, 18% were high school graduates, and 8% had higher education levels. In the mechanic group, 36% had elementary education, 40% had a middle school education, 22% had a high school education, and 2% had higher education levels. 96% of carpenters were married, and 4% were single, compared to 94% married and 6% single in the mechanic group.

Regarding residence location, 88% of carpenters were living in urban and 12% in rural areas, while 82% of mechanics were from rural and 18% from urban. 16% of respondents in the carpenter group described their economic status as poor, 80% as intermediate, and 4% as good level, while 14% in the auto mechanic group had a poor and 86% a medium economic status. Cross table 4 provides the frequency of diabetes in carpenters and mechanics. The Chi-square test indicates no significant difference in diabetes incidence between the two groups (p=0.079).

Table 4. The frequency distribution of diabetes between carpenters and auto mechanics under study.

Crosstab					
			Occupation		**Total**
			Auto mechanic	**Carpenter**	
Diabetes development	Yes	Count	0	3	3
		% within diabetes involvement	0.0%	100.0%	100.0%
		% within job	0.0%	6.0%	3.0%
		% of total	0.0%	3.0%	3.0%
	No	Count	50	47	97
		% within diabetes involvement	51.5%	48.5%	100.0%
		% within job	100.0%	94.0%	97.0%
		% of total	50.0%	47.0%	97.0%
Total		Count	50	50	100
		% within diabetes involvement	50.0%	50.0%	100.0%
		% within job	100.0%	100.0%	100.0%
		% of total	50.0%	50.0%	100.0%
p-value	0.079				

The Chi-square test demonstrated no significant difference between the carpenters and auto mechanics regarding the waist circumference size (p=0.280), family history of diabetes (p=0.079), smoking or non-smoking (p=0.181), the number of cigarettes smoked (p=0.052), regular physical activity (p=0.834), the type of oil used (p=0.287), the types of unhealthy foods consumed (p=0.801), the number of hours of sleep (p=0.195), perceived stress (p=0.022), presence or absence of coexisting diseases (p=0.065), history of medication usage or not (p=0.227), and ethnicity (p=0.227). However, the odd ratio assessment suggested a higher incidence of stress in the carpenter group (OR=0.286; 0.094-0.868). The OR value is calculated as the ratio between the mechanic and the carpenter.

Discussion

The present study revealed no statistically significant difference in FBS levels between auto mechanics and carpenters. Given the obtained mean and standard deviation values, the only significant difference was found for daily work duration (hour) (p=0.003), and other reported variables were not significantly different. No significant difference in diabetes development was noticed between the carpenters and mechanics. The measurement results of blood glucose levels in patients found no significant association between diabetes incidence and occupational exposure to chrome and vanadium.

The number of diabetic patients is rapidly growing worldwide, especially in Asian countries. Thus, some studies have focused on developing more effective treatments for diabetes than conventional therapies, including using trace elements such as chromium and vanadium. Of note are the studies by Mustafa Ulas et al. and Payami et al. [13, 14, 15, 16], which used chromium for glycemic control, and also Muhammadi et al. [17] and Amini et al. [17], which proposed vanadium compounds for this purpose. Palizban et al. evaluated the blood concentration of vanadium and chromium in metabolic syndrome patients with and without type 2 diabetes [4].

The primary aim of the current study was to compare the studied units in two job groups with different working conditions in terms of skin contact with trace elements, namely chromium and vanadium. The study sought to determine whether a significant difference in diabetes incidence can be found between the two groups considering their different occupational exposures. While three carpenters compared to no mechanic were diabetic, the statistical analysis failed to establish a significant difference in diabetes incidence between the two groups. It is, therefore, not possible to conclude that occupational exposure to elements such as chromium and vanadium can play a preventive role in diabetes.

In their study, Palizban et al. measured the blood concentration of vanadium and chromium in metabolic syndrome patients with and without type 2 diabetes. Their results suggested a relationship between the blood levels of measured elements with the incidence of diabetes and metabolic syndrome. Thus, the measurement and supplementation of these elements can prevent the occurrence or progress of this illness [4]. It is likely that the present study might have yielded different results if it had been conducted with a larger sample size or assessed the serum levels of chromium and vanadium and their skin absorption and their relationship with diabetes incidence. Therefore, the results could have corroborated those of other similar studies. Thus, evaluating the skin absorption of chromium and vanadium in various occupational groups, like auto mechanics, who deal with such alloys on a daily basis could be helpful in identifying the exact role of these elements in diabetes.

The two groups presented no significant difference in demographic variables, including education level, marital status, residence, and economic status. In addition, no significant difference was observed between the two groups in terms of waist circumference size, family history of diabetes, smoking or not smoking, the number of cigarettes smoked, regular physical activity, the type of oil consumed, the types of unhealthy foods consumed, number of hours of sleep, perceived stress, underlying diseases, history of medication usage or not, and ethnicity. However, the risk factor assessment based on the studied units in this research indicated that a family history of diabetes was associated with a 2.538 times higher chance of diabetes incidence (OR=2.538; 0.811-7.943). Mehvarifar et al. reported the prevalence of diabetes in the first-degree relatives of diabetic patients to be 18.7 percent [18]. In an Argentinian study by Seiwert et al., the diabetes prevalence was estimated as 58% in first-degree relatives [19].

The advance of age is accompanied by reduced physical activity and lower self-care, which, in turn, can affect the quality of metabolic control in people. Numerous studies have highlighted the significant relationship between age and A1C hemoglobin. In most studies, the association between gender and A1C hemoglobin was insignificant. The better metabolic control in males reported in some studies has been attributed to higher physical activity and exercise levels in men compared to women [5, 20]. The glycemic control status is more favorable in employed patients than those unemployed and retired, or housewives [5]. Testa and Simonson have reported the beneficial effects of the favorable economic status on improving glycemic control in diabetic patients [16]. In the study by Al Omari in Jordan, the non-smoking patients showed better glycemic control [17]. The results of the Heiz et al. study (2008) suggest that one in three people utilize complementary medicine to prevent or treat conditions such as type 2 diabetes. Natural products more frequently used in diabetes prevention and treatment include chromium, garlic, ginseng, alpha-lipoic acid, and over 50 herbal supplementations
[21]. Recently, a deficiency in trace elements in the body has been proposed as a risk factor for diabetes [4, 22]. The reduction of trace elements such as chromium and vanadium causes a rise in insulin resistance, whose incidence or progress is preventable by diet modification and supplementation. While modifying the levels of essential trace elements, particularly chromium and vanadium, plays a significant role in diabetes mellitus, their role in metabolic syndrome incidence is less understood [4]. Anderson is among the researchers who have extensively explored the relationship between chromium and diabetes. He believes chromium counteracts diabetes by improving the antioxidant defense mechanism in the body (which is more sensitive than insulin or glucose variations) rather than directly affecting the insulin or glucose function. The insulin function is then improved as a result of the antioxidant effects. Onderci reached the same conclusion by studying the impact of chromium on antioxidants [23]. Vanadium is another essential element with significance in metabolic syndrome and diabetes incidence [4]. By enhancing the sensitivity of insulin receptors in bodily tissues, vanadium can demonstrate its blood glucose-lowering effects, and in enough time, it can exert its regenerative effects on the pancreas. Cohen et al. reported improved hyperglycemic control in patients with type 2 diabetes after three weeks of vanadyl sulfate consumption [7]. It is now believed that vanadium and chromium have a synergistic effect in their activities, i.e., they are more effective in combination than individually [4]. Chromium-vanadium alloys are useful in many applications, including scratch-proof metal surfaces, surgical instruments, manufacturing equipment, and tools such as wrenches [8, 9]. Considering the high solubility of organic metal compounds in fat, they can easily be absorbed via the skin [9]. Based on these considerations, occupational exposure to these types of alloys and exposure duration, especially in people working in technical jobs, such as auto mechanics, can be associated with skin absorption of chromium and vanadium and, consequently, the reduced risk of diabetes.

The current study faced some limitations, including the small sample size and restrictions in clinical and para-clinical procedures, which were tackled by promoting further coordination and collaboration. More comprehensive research is suggested to evaluate and compare the degree of skin absorption of chromium and vanadium in different occupation groups, specifically technicians such as auto mechanics who regularly deal with these alloys. Moreover, attention to a healthy diet, prevention of excess weight gain, and regular exercise seem necessary [24-26]. Providing exercise facilities, particularly in hazardous and physically demanding occupations, is crucial [27]. Follow-up and control of cases with confirmed diagnoses can reduce, to a large extent, the subsequent complications of this disorder.

Conclusion

The results suggested no statistically significant association between occupational exposure to chromium and vanadium and diabetes development. Nevertheless, annual examinations and tests are recommended for early diagnosis of these patients and prevention of associated disorders.

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References

1. Fauci, A. S. (2015). Harrison's principles of internal medicine. McGraw-Hill Education.
2. Fatehi M. (2000). In translation of practical guideline for adults who have diabetes: author: Hilton. Ghoghnus publications. Second edition, Tehran. (in Persian)
3. Heisler, M., Smith, D. M., Hayward, R. A., Krein, S. L., & Kerr, E. A. (2003). How well do patients' assessments of their diabetes self-management correlate with actual glycemic control and receipt of recommended diabetes services?. Diabetes care, 26(3), 738-743.
4. Razani, R., Rezaei, M., Badii, A., & Pourfarzam, M. (2016). The investigation of blood concentration of Vanadium and Chromium in metabolic syndrome patients with and without type 2 diabetes. yafte, 18(1).
5. Getri(2002) Basics of nutrition. Translated by Minoo Forouzani. Tehran. Chehr Publications. Sixth edition. pp. 298-213.
6. Zahra, T., Rahmatollah, R., Zahra, H., Lotfollah, F., Somayeh, Z.,ea.al. (2014). Chromium serum levels in people with pre-diabetes. Journal of Isfahan Medical School. 32. No. 273. pp. 66-59.
7. Ali, A., Paria, P., Namdar, Y.. Effects of oral concomitant use of zinc sulfate and vanadium on blood sugar levels in diabetic rats with streptozotocin. Journal of Fasa University of Medical Sciences. Winter 1394. Year 5. No. 4. pp: 577-571.
8. Flynn, S., Hulbert-Williams, N., Hulbert-Williams, L., & Bramwell, R. (2015). Psychosocial experiences of chronic illness in individuals with an intellectual disability: A systematic review of the literature. Journal of Intellectual Disabilities, 19(2), 178-194.
9. http://safety message.com/education hazard-material/843-2014-06-05-20-13-39.
10. Vimalananda, V. G., Palmer, J. R., Gerlovin, H., Wise, L. A., Rosenzweig, J. L., Rosenberg, L., & Ruiz Narváez, E. A. (2015). Night-shift work and incident diabetes among African-American women. Diabetologia, 58(4), 699-706.
11. Ford, S. (2015). Diabetes risk higher in black women who work night shifts. Nursing times, 1, 1.
12. Lawton, J., Kirkham, J., White, D., Rankin, D., Cooper, C., & Heller, S. (2015). Uncovering the emotional aspects of working on a clinical trial: a qualitative study of the experiences and views of staff involved in a type 1 diabetes trial. Trials, 16(1), 1-11.
13. Peyami, P., Sara, S., Hassanzadeh. (2012.(Determining the effect of chromium on blood sugar control in patients with type 2 diabetes. Journal of Endocrine and Metabolism of Iran. September. Volume 14. Number 3. pp: 221-215.
14. King, H. (1999). WHO and the International Diabetes Federation: regional partners. Bulletin of the world Health organization, 77(12), 954.
15. Warren, R. E. (2004). The stepwise approach to the management of type 2 diabetes. Diabetes research and clinical practice, 65, S3-S8.
16. Ulas, M., Orhan, C., Tuzcu, M., Ozercan, I. H., Sahin, N., Gencoglu, H., ... & Sahin, K. (2015). Anti-diabetic potential of chromium histidinate in diabetic retinopathy rats. BMC complementary and alternative medicine, 15(1), 1-8.
17. Taghi, M. M., Fakhreddin, M., Abbas. D. G., (2007) . Renal effects of vanadium on pancreatic beta cells in rats with relatively severe diabetes mellitus. Journal of Endocrine and Metabolism of Iran. September. Volume 9. Number 2. pp: 140-133.
18. Najmeh, M., Marzieh, S., Leila, A., Maryam, Z., Ahmad, I., Massoud, A. Prevalence of metabolic syndrome and metabolic risk factors in first-degree healthy relatives of type 2 diabetic patients. Journal of Diabetes and Metabolism in Iran. 1387; 7 (3): 314-305.
19. Santos, J. L., Pérez-Bravo, F., Carrasco, E., Calvillán, M., & Albala, C. (2001). Low prevalence of type 2 diabetes despite a high average body mass index in the Aymara natives from Chile. Nutrition, 17(4), 305-309.
20. King H, who and the international diabetes federation: Regional partners. Bulletin of the world health organization. 2010. 77(12).
21. Hays, N. P., Galassetti, P. R., & Coker, R. H. (2008). Prevention and treatment of type 2 diabetes: current role of lifestyle, natural product, and pharmacological interventions. Pharmacology & therapeutics, 118(2), 181-191.
22. Susan S. Smelter- Branda J. Bir- Janis L. Hinkel-Kerry H. (2011). Chivir - translated by Nahid Dehghan Nairi. Ahmad Ali Asadi Noghabi Publication of Negah-e-Salami. Second Edition, Tehran: pp. 233-149.
23. Anderson, R. A. (2000). Chromium in the prevention and control of diabetes. Diabetes and metabolism, 26(1), 22-28.
24. Assadi, S. N. (2014). Risk of early menopausal symptoms in clinical workers. Iranian Journal of Nursing and Midwifery Research, 19(6), 569.
25. Assadi, S. N. (2013). Cardiovascular disorders risk factors in different industries of Iran. International journal of preventive medicine, 4(6), 728.
26. Assadi, S. N. (2013). Comparison the frequency of symptoms of acute shift work maladaption syndrome between two groups of shift workers. Iran Occupational Health, 10(6), 70-77.
27. 27. Assadi, S. N. (2017). What are the effects of psychological stress and physical work on blood lipid profiles?. Medicine, 96(18).