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Research Paper:
Color Vision in the Gas Station Workers of Isfahan City: A Quantitative Analysis With the Farnsworth D15 Color Test

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Conflict of interest
The authors declared no conflict of interest.

ABSTRACT

Background and Objectives: The color vision evaluation of gas station workers in Isfahan City.

Methods: This cross-sectional comparative study was performed on workers at gas stations in Isfahan; all the workers were men. The participants were divided into two 40-people groups of exposure and non-exposure (the members of the fuel sales department). The participants had better vision than 8/10 and no underlying problems or eye disease. Besides, examination, including color vision was performed for all subjects. Color vision was assessed using the D15 test under high to medium light conditions. Also, the color vision test was performed monocularly. Then, the obtained data were analyzed using SPSS V. 22.

Results: The two study groups significantly differed in terms of color vision impairment index ($P<0.001$). Also, more color vision defects were seen in the group exposed to gasoline. The color confusion index (as the indicator of color vision defects) were 1.485 and 1.129 in exposure and non-exposure to gasoline groups, respectively. Thus, color vision defects were significantly higher in the exposure to gasoline group, compared with the control group.

Conclusion: The results of this study showed a difference in color vision index between the two groups. Therefore, long-term exposure to organic solvents, such as gasoline in fuel stations may cause color vision loss.

Keywords: Colour vision, Occupational exposure, Gas

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What is "already known" in this topic:

Studies have observed color vision deficiency following exposure to benzene petroleum products in industries.

What this article adds:

This research has investigated the occupational exposure to gasoline in Iran, because of the country's population, different climatic conditions, gasoline consumption, and the number of fuel stations as an import than target community for this field of research.

1. Introduction

Petroleum products, including gasoline, are widely used in the industry. Research shows that these products affect the nervous system directly and cause disorders [1]. Most of these products, including gasoline, are lipophilic and volatile at room temperature. Because of this property, they tend to attach or adhere to high-fat tissues, such as brain tissue and myelin. This property poses a risk to health [2].

Petroleum products (such as gasoline) at low or medium concentrations can cause transient symptoms in the central nervous system, such as headache and dizziness. At high concentrations, they can cause disturbances in consciousness, respiratory failure, circulatory system problems, or even death in some cases [1].

Research to date has shown that these products cause changes in various parts of the visual system, such as the lens, retinal layers, and optic nerve. Also, the neurological damage caused by chronic or acute occupational exposure to petroleum products can cause acquired color blindness, including yellow-blue or green-red color blindness [2]. Visual dysfunction can indicate neural changes in the peripheral system. Since color vision deficiency is probably the result of damage to ocular structures, it is possible to diagnose color vision deficiency before patients are aware of functional damage [3].

The employees of gasoline stations are exposed to petroleum products in long work shifts, thus, they are exposed to vapors emanating from gasoline materials by breathing in air. These vapors are also absorbed by the eyes [3].

Oil-rich countries or oil-producing countries are among the most important target communities for these disorders. Besides, some research has been done on the effects of gasoline on visual functions, including color vision [3, 4].

However, no research has investigated the occupational exposure to gasoline in Iran, because of the country's population, different climatic conditions, gasoline consumption, and the number of fuel stations as an important target community for this field of research. Therefore, it is of great importance to evaluate color vision in the community of Iranian fuel stations in Isfahan City as one of the metropolises of the country, which is world-famous and has a lot of traffic [5, 6]. The results can be suitable for explaining warnings and preventive planning regarding job protection.

2. Methods

This cross-sectional study was performed on the gas station workers of Isfahan City, all of whom were male. Participants were divided into two 40-people groups of exposure and non-exposure (members of the fuel sales department).

The desired tests were performed on each person. Tools are needed to perform these tests and examinations. First, the far and near visual acuity of the person was taken using the Snellen chart with and without glasses. The best vision of the person (ie, the row of the Snellen chart that was seen by the person) was recorded as far and near visual acuity in the questionnaire. Then, people with near and far visual acuity of 8/10 or better with and without correction were selected. Also, all of the examinees had a work history of more than five years and no history of any underlying diseases, such as diabetes, hypertension, and thyroid problems; they were also taking no medications. Moreover, the participants did not have a history of eye diseases, such as cataracts, glaucoma,

Table 1. Comparison of age and work experience in gas station workers with and without gasoline exposure

Variable	Group	Range	Mean±SD	T	P
Age, y	Exposure	30-70	47.95± 1.734	4.916	<0.001
	No exposure	27-54	37.80±1.122		
Work experience, y	Exposure	8-40	19.68±1.488	4.537	<0.001
	No exposure	3-21	12.10±0.758		

or any other diseases, all of which were recorded in the examination form.

The next step was to perform the Farnsworth D15 color vision test. Color vision tests, particularly the Farnsworth D15, are sensitive to color vision defects caused by toxic substances. Although the use of more than one color vision test may help diagnose color vision defects, the Farnsworth D15 has been more sensitive than other color vision evaluation tests [7].

This test consists of 15 dots with different colors in terms of saturation. The examinee must arrange and write the order of the numbers behind them. There was no time limit for performing this test. The Color Confusion Index (CCI) is calculated by dividing the sum of the distances between the colored beads that the examinee arranged in the Farnsworth D15 color vision test by the sum of the standard bead distances (correct arrangement), which is a number equal to 56.4. The final number called CCI was obtained and interpreted quantitatively [8]. The minimum value of CCI is one; values higher than one indicate color vision impairment. Each eye was examined separately in high mesopic light conditions and at a distance of 50 cm from the person because the acquired color vision defect can be monocular and asymmetric [9].

The obtained data were statistically analyzed with SPSS, version 22. Besides, descriptive statistical indicators, such as mean table and standard deviation were used to describe the data. The normal distribution of data was confirmed by the Kolmogorov-Smirnov test. Then, the independent t-test was used to evaluate and compare the mean and standard deviation of the exposure and non-exposure groups. The significance level of the tests was considered 0.05.

3. Results

This study examined the color vision of the right and left eyes in 80 men. The mean age and work experience of the group exposed to gasoline were 47.95 years and 19.68 years, respectively; in the group not exposed to gasoline, these values were 37.80 years and 12.10 years, respectively.

Table 1 shows the central indicators and the dispersion of age and work experience in gas station workers with and without gasoline exposure. There was a statistically significant 10-year age difference and about seven years of work experience difference between the two groups. Thus, we investigated the confounding effect of age and work experience on the color vision variable.

Table 2 shows the average index of right eye color impairment in gas station workers with and without gasoline exposure. The average CCI of the right eye was 1.485 and 1.129 in the exposed and nonexposed to gasoline groups, respectively.

The right eye CCI was compared between the exposed and nonexposed to gasoline groups, using the independent t-test. The value of the test statistic was 81.31, and the value of P was less than 0.001 (less than 0.05). So the right eye CCI significantly differs between the two study groups.

Table 2. Comparison of right eye color confusion index between gas station workers with and without gasoline exposure

Group	Range	Mean±SD	T	P
Exposure	1.06-1.97	1.485±0.0405	8.312	<0.001
No exposure	1.02-1.35	1.129±0.0137		

Table 3. Comparison of Left Eye Color Confusion Index Between Gas Station Workers With and Without Gasoline Exposure

Group	Range	Mean±SD	T	P
Exposure	1.09-2.12	1.533±0.0383	9.555	<0.001
No exposure	1.04-1.35	1.147±0.0129		

Table 3 shows the mean CCI of the left eye in gas station workers with and without gasoline exposure. The average CCI of the left eye was 1.533 and 1.147 in the group exposed to gasoline and the group not exposed to gasoline, respectively.

The left eye CCI was compared between the two groups of exposure and non-exposure to gasoline, using the independent t-test. The value of the test statistic was 9.555, and the value of P was less than 0.001 (less than 0.05). So the left eye CCI significantly differs between the two study groups.

The two groups of exposure and non-exposure to gasoline differed in the mean age and work experience. Therefore, the confounding effect of age and work experience on the CCI of the right and left eye were examined using the analysis of covariance. No distorting effect was observed, considering the P values that were equal to 0.556 and 0.436 for age and work experience, respectively. Consequently, age and work experience were not distorting variables, and no significant relationships existed between these variables and CCI. Although the average age and work experience differed between the two groups, the lack of distorting effect confirmed the significant relationships obtained owing to exposure to gasoline in gas station workers.

4. Discussion

This study investigated the effect of exposure to gasoline on workers at fuel stations in Isfahan City. The results showed that the group exposed to gasoline significantly suffered from color vision impairment.

Previous studies have also evaluated the color vision changes due to occupational exposure, using the Farnsworth D15 color vision test. The present study found that exposure to gasoline in workers at gas stations in Isfahan caused color vision defects. Also, a study by Gang et al. in Japan, 2003, revealed color vision impairment and color vision deficiency in workers who were exposed to a combination of organic solvents, compared with the control group [1]. This is consistent with the results of the present study on color vision.

Also, the color vision disorder obtained in this study is consistent with the results of Chong et al., 2006. These researchers investigated the acquired color vision in workers at a large petrochemical distillery in Australia. The authors evaluated color vision at the low, medium, and high concentrations of gasoline, using the Farnsworth D15 color vision test. Besides, research has shown that even chronic exposure to the low levels of organic solvents can increase the rate of color vision impairment, resulting in acquired color vision deficiency. The nervous system is the first target organ for the toxic effects of gasoline and solvents, and the lack of color vision is the first sensitive sign of destructive neurotoxicity [2].

In Siluria's study, the result of color vision deficiency is similar to the result of the present study. A 2012 study in Brazil examined the relationship between the color vision and non-color vision of gas station workers who were exposed to organic solvents. Color visual impairment in workers was more than in the control group; this is similar to the present result on color vision impairment [4].

In 2012, Costa et al. assessed the color vision of 25 workers at a gas station, compared with a control group. The values of CCI in the experimental group were higher than the control group, indicating color vision deficiency in workers [10].

Similar results of the present study in terms of the effect of gasoline on the development of acquired color vision defects have been observed in other studies that have evaluated occupational exposure to substances, such as manganese, gasoline, mercury vapor, and organic solvents [11, 12]. The findings of various studies and the present study on the lack of color vision in the field of occupational exposure show that contact with petroleum products, such as gasoline, negatively affects color vision and can lead to impaired color vision.

5. Conclusion

According to the results of the present study, the chronic occupational exposure of workers at gas stations in Isfahan to gasoline products can harm color vision and cause color vision defect.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Iran University of Medical Sciences. (Code: IR.IUMS.REC.1399.249).

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Authors' contributions

General design, data collection, analysis, and discussion: Asieh Sadat Sedighi; Data analysis: Ali Mirzajani; General design and data presentation: Jamileh Abolghasemi; Discussion: Ebrahim Jafarzadehpur.

Conflict of interest

The authors declared no conflict of interest.

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چشم‌انداز رنگ در کارگران پمپ بنزین شهر اصفهان: تجزیه و تحلیل کمی با آزمون رنگی Farnsworth D15

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چکیده

مقدمه فرآورده‌های نفتی از جمله بنزین به طور گسترده در صنعت استفاده می‌شوند و تحقیقات نشان می‌دهد که این نوع حلال‌ها تأثیر مستقیمی بر روی سیستم عصبی داشته و موجب بروز اختلالات می‌شود. بررسی اینگونه اختلالات در افراد مواجهه با بنزین در جایگاه‌های سوخت می‌تواند مفید باشد و آگاهی‌های لازم به افراد شاغل داده شود.

مواد و روش‌ها این مطالعه مقطعی ـ مقایسه‌ای در کارگران جایگاه‌های پمپ بنزین در شهر اصفهان که تمامی مرد بودند، انجام شد. افراد شرکت‌کننده به دو گروه مواجهه به تعداد ۴۰ نفر و گروه بدون مواجهه (افراد بخش اداری خرید و فروش سوخت) به تعداد ۴۰ نفر تقسیم شدند. تمام افراد حدت بینایی بهتر از ۸/۱۰ داشتند و هیچ گونه مشکل زمینه‌ای و یا بیماری چشمی نداشتند. معاینات دید رنگ برای تمام افراد انجام گرفت. دید رنگ با استفاده از آزمون D15 تحت شرایط نوری متوسط بالا بررسی شد. داده‌ها با استفاده از نرم افزار SPSS نسخه ۲۲ مورد تجزیه و تحلیل قرار گرفتند.

یافته‌ها نتایج تحقیق نشان داد که در مورد شاخص اختلال دید رنگ در بین دو گروه مورد مطالعه تفاوت معناداری وجود داشت (P-value<۰،۰۰۱).

نتیجه‌گیری نتایج این مطالعه نشان داد با توجه به تفاوت موجود در شاخص اختلال دید رنگ، در معرض قرار گرفتن طولانی مدت با حلال‌های ارگانیک مانند بنزین در جایگاه‌های سوخت، می‌تواند موجب نقص دید رنگ شود.

کلیدواژه‌ها:
دید رنگ، مواجهه شغلی، بنزین

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