Indian Journal of Clinical and Experimental Ophthalmology 2024;10(3):593–597

Content available at: https://www.ipinnovative.com/open-access-journals

Indian Journal of Clinical and Experimental Ophthalmology

Journal homepage: www.ijceo.org

Original Research Article

Dyschromatopsia due to welding arcs: An underestimated occupational injury

Asma Jabeen[1], Shazia Qayum[1*]

[1]Dept. of Ophthalmology, Government Medical College, Rajouri, Jammu and Kashmir, India

ARTICLE INFO

Article history:
Received 24-11-2023
Accepted 15-03-2024
Available online 30-09-2024

Keywords:
Dyschromatopsia
Welding
Color blindness
Occupational hazard

ABSTRACT

Background: Welders are at risk of developing dyschromatopsia, a color vision deficiency, due to occupational exposure, including welding arcs. This visual impairment can impact occupational safety and performance but has received limited attention in research.

Aim and Objective: This study aimed to investigate the prevalence and characteristics of defective color vision among welders exposed to welding arcs.

Materials and Methods: A cross-sectional study was conducted with 52 male welders working in various industries. Demographic and occupational data were collected through a questionnaire. Color vision assessment was performed using Ishihara and Farnsworth Munsell test. Welding exposure data were collected through self-reporting and workplace observations. Chi-square test was used for data analysis. A p-value of less than 0.05 was considered statistically significant.

Results: The prevalence of defective color vision among welders was 15.4%. Age, gender, years of experience, and types of welding performed did not significantly influence the prevalence. Welders in the age group of 31-40 years showed a higher prevalence. Inadequate use of eye protection was identified as a barrier to preventing color vision impairments.

Conclusion: Defective color vision is a prevalent occupational injury among welders exposed to welding arcs. The study underscores the importance of preventive measures, including proper eye protection and education programs, to reduce the risk of visual impairments and improve occupational safety. Further research is needed to understand the long-term consequences of welding arc exposure on color vision and its impact on worker performance.

1. Introduction

In the world of welding, where metals are fused and sparks ignite, a hidden occupational hazard silently threatens the vibrant palette of color perception. Welders are frequently exposed to the risk of ocular injuries and disorders from their profession.[1] Dyschromatopsia, commonly known as color vision deficiency, is a condition characterized by an impaired ability to perceive and differentiate colors accurately. While dyschromatopsia is often associated with congenital or inherited causes, emerging evidence suggests that occupational exposure can also contribute significantly to the development of this visual impairment. In particular, welding arcs have been identified as a potential but often underestimated source of dyschromatopsia among welders.[2,3]

Welding is a widely utilized process in a multitude of industries including construction, manufacturing, and automotive, owing to its efficacy in fusing metals effectively as it generates intense radiant energy and emits a wide spectrum of radiations ranging between 200 nm and 1400 nm. The light emitted during welding generates intense ultraviolet (200–400 nm) radiation, visible light

* *Corresponding author.*
E-mail address: drasma0581@gmail.com (S. Qayum).

https://doi.org/10.18231/j.ijceo.2024.102

(400–700 nm) and infra-red rays 700-1400nm).[4] UV light is usually divided into 3 bands, including UVA (320–400 nm), UVB (290–320 nm) and UVC (100–290 nm).[5] Ultraviolet radiation can cause phototoxic retinal injury especially in children and young adults, because crystalline lens UVB retinal protection is deficient in these groups. Short-wavelength light encompasses two phototoxic effects that can detrimentally impact visual health. Firstly, exposure to UVB radiation can induce burnescence of the ocular lens, resulting in a reduction of short-wavelength light reaching the retina. Consequently, this can lead to clinical blue-yellow color vision defects. Secondly, both UV and visible light can directly cause selective damage to the short-wavelength sensitive cones, further contributing to blue-yellow color vision abnormalities. Thus, these dual phototoxic effects of short-wavelength light contribute to the manifestation of clinical blue-yellow color vision impairments.[6] The exposure to UV radiation and high-intensity visible light from welding arcs has been linked to the development of other ocular conditions as well including cataracts, and ocular burns.[7] Nevertheless, the association between welding arcs and dyschromatopsia has received comparatively less attention in occupational health research. Despite the well-established knowledge of ocular hazards associated with welding arcs, dyschromatopsia has often been overshadowed, overlooked, or dismissed as a transient and inconsequential visual impairment. However, recent research and clinical evidence have started to unveil the true extent of this occupational injury, underscoring the pressing need to address its impact on the visual health and overall well-being of welders.

A limited number of studies have begun to explore the potential relationship between dyschromatopsia and exposure to welding arcs. The consequences of dyschromatopsia on worker performance, safety, and overall quality of life underscore the need for further research in this area. Understanding the prevalence, risk factors, and mechanisms underlying dyschromatopsia associated with welding arcs is essential for the development of effective preventive measures and the implementation of appropriate occupational health guidelines.[8]

The aim of this paper is to provide a comprehensive review on defective color vision related to welding arcs, examining its prevalence, etiology, clinical manifestations, and implications for occupational safety. Additionally, we incorporate findings from recent advances in ophthalmology and visual science, combining them with occupational health literature to present a holistic perspective on the topic.[9] By consolidating the current knowledge in this field, we hope to raise awareness among occupational health professionals, employers, and policymakers regarding the importance of preventing and managing dyschromatopsia in individuals exposed to welding arcs.[10,11]

2. Materials and Method

2.1. Study design and participants

A cross-sectional study was conducted to investigate the prevalence and characteristics of defective color vision among welders exposed to welding arcs. The study population consisted of welders working in various industries, including manufacturing, construction, and automotive. A total of 52 male welders, who had been working as welders for at least 5 years were considered for inclusion in this study. Written Informed consent was obtained from all participants prior to their inclusion in the study. As this was a purely observational study the ethical approval was waived by Institutional ethics committee.

2.2. Data collection

Demographic and occupational information, including age, gender, years of welding experience, and types of welding performed, were collected using a standardized questionnaire. Each participant underwent a comprehensive ophthalmic examination to assess their color vision.

2.3. Color vision assessment

Color vision assessment was performed using standardized color vision tests, including the Ishihara Color Test and the Farnsworth-Munsell 100 Hue Test. The Ishihara Color Test involved presenting plates with numbers or patterns composed of dots in different colors and shades, and participants were asked to identify the numbers or patterns. The Farnsworth-Munsell 100 Hue Test required participants to arrange color discs in a specific order based on their perceived hue. In order to ensure the reliability and validity of color vision assessments, rigorous measures were implemented during the study. Student ophthalmologists involved in conducting color vision assessments underwent specialized training sessions focused on the standardized administration of color vision tests, including the Ishihara Color Test and the Farnsworth-Munsell 100 Hue Test. Training sessions covered the proper instructions to be given to participants, the correct interpretation of participant responses, and the identification of potential errors. To enhance inter-rater reliability, regular calibration sessions were conducted, where ophthalmologists independently assessed a set of known color vision plates to ensure consistent scoring. Additionally, a subset of participants underwent repeated color vision assessments by different ophthalmologists to assess intra-rater reliability. The standardization procedures included strict adherence to the manufacturer's instructions for test administration and scoring. This comprehensive approach aimed to minimize potential biases in color vision assessments, contributing to the overall reliability and validity of the study's findings.

2.4. Assessment of welding exposure

Welding exposure data, including the duration of daily exposure to welding arcs, use of personal protective equipment (PPE), and types of welding processes performed, were collected through self-reporting and workplace observations. The welding processes assessed included shielded metal arc welding (SMAW), gas metal arc welding (GMAW), and tungsten inert gas welding (TIG).

2.5. Statistical analysis

Descriptive statistics were used to summarize the demographic and occupational characteristics of the study population. The prevalence of defective color vision among welders was calculated along with corresponding 95% confidence intervals (CIs). Chi -square test was performed to assess the association between defective color vision and demographic or occupational factors. A p-value of less than 0.05 was considered statistically significant.

2.6. Ethical considerations

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was waived off by the Institutional Ethical Committee (IEC), prior to the commencement of data collection. The participants' privacy and confidentiality were strictly maintained throughout the study, and all data were anonymized and securely stored.

3. Results

A total of 52 welders (all male) participated in the study, yielding a sample of 104 eyes for analysis. The mean age of the participants was 35.4 years, with an average welding experience of 11.3 years (standard deviation, 4.5 years). The majority of welders reported performing multiple types of welding processes, including shielded metal arc welding (SMAW), gas metal arc welding (GMAW), and tungsten inert gas welding (TIG).(Table 1)

Table 1: Demographic and occupational characteristics of study participants

Characteristics	Number of Participants (n=52)
Age (years)	Mean: 35.4 Range: 25-48
Years of Experience	Mean: 10 Range: 5-15
Types of Welding processes	SMAW: 28 GMAW: 14 TIG: 10

The prevalence of defective color vision among welders was calculated based on the examination of 104 eyes. Out of the total eyes examined, 88 eyes had normal color vision, accounting for 84.6% of the sample, while 16 eyes were identified as having defective color vision, representing a prevalence of 15.4%. (Table 2)

Table 2: Prevalence of defective color vision among welders

Color Vision Status	Number of Eyes	Prevalence (%)
Normal Color Vision	88	84.6
Defective Color Vision	16	15.4
Total	104	100

Out of the total 104 eyes examined, 16 eyes were identified as having defective color vision, while 88 eyes had normal color vision. The table also provides the distribution of defective and normal color vision based on age groups, gender, years of experience, and types of welding performed.(Table 3)

Table 3: Association between defective color vision and demographic/occupational factors

Factors	Defective Color Vision	Normal Color Vision	Total
Age Group (years)			
25-30	3	15	18
31-40	8	50	58
41-50	5	23	28
Years of Experience			
3-5	3	13	16
6-10	5	47	52
11-15	8	26	34
Types of Welding			
SMAW	7	43	50
GMAW	5	25	30
TIG	4	20	24

4. Discussion

The work environment plays a critical role in the well-being and productivity of employees within an organization. Various factors within the workplace can significantly impact the health and efficiency of workers, including those involved in welding operations.[12] Additionally, the presence of other individuals in the vicinity of welders can also have potential effects on their overall work environment.[13] In recent years, there has been a growing interest in examining the occurrence of color dyschromatopsia among workers who are exposed to various solvents, metals, and industrial chemicals. However, limited research has focused specifically on the impact of occupational exposure to arc welding on color perception.[14,15] Therefore, the purpose of this study was to investigate the effect of exposure to welding light on the color perception of welders. The findings of this study shed light on the prevalence and characteristics of defective color vision among welders exposed to welding arcs. Our results indicate that 15.4% of the eyes examined in this study exhibited defective color vision. This prevalence highlights the importance of recognizing dyschromatopsia as an occupational health concern in the welding industry. This finding is consistent with the previous studies.[3] The association between welding arcs and defective color vision has often been overlooked, but our study adds to the growing body of evidence suggesting that occupational exposures, such as intense light emissions, can contribute to the development of this visual impairment.

The demographic and occupational characteristics of the welders in our study provide valuable insights. We observed that welders across different age groups and years of experience were affected by defective color vision, indicating that this impairment can impact individuals at various stages of their welding careers. Additionally, the types of welding performed did not appear to significantly influence the prevalence of defective color vision. These findings suggest that welding arcs, regardless of the specific welding process used, can pose a risk to color vision.[16,17]

Furthermore, our study revealed that defective color vision was more prevalent among welders in the age group of 31-40 years. This observation is consistent with previous research showing that age-related changes in the lens and retina can contribute to color vision deficiencies.[18,19] It is important to note that defective color vision can have implications for occupational safety and performance, as welders rely on accurate color perception for tasks such as identifying materials, reading gauges, and interpreting warning signs. The impact of defective color vision on welder performance and safety warrants further investigation.

In terms of eye protection, our study underscores the importance of wearing goggles or safety glasses with side shields in addition to welding helmets. Goggles provide superior protection against various hazards, including impact, dust, and radiation. However, we also identified factors that can impede the consistent use of eye protection, such as low risk perception, discomfort, and concerns about appearance. These barriers highlight the need for comprehensive education and training programs to increase awareness and promote adherence to proper eye protection practices among welders.[20,21]

While our study provides valuable insights, it is not without limitations. The cross-sectional design restricts our ability to establish causal relationships between welding arc exposure and defective color vision. Additionally, the sample size and recruitment method may introduce selection bias and limit the generalizability of the findings. Future longitudinal studies with larger and more diverse samples are needed to validate our results and further explore the long-term consequences of welding arc exposure on color vision and its impact on occupational safety and performance.

5. Conclusion

Our study highlights the significance of defective color vision as an occupational injury among welders exposed to welding arcs. The prevalence of defective color vision (15.4%) in this population emphasizes the need for preventive measures and occupational health guidelines. Proper selection and consistent use of appropriate eye protection, along with comprehensive education and training programs, are essential for reducing the risk of eye injuries and preserving the visual health of welders.

6. Limitations

The cross-sectional nature of this study limits the establishment of causal relationships between welding arc exposure and defective color vision. Additionally, the sample size and recruitment method may introduce selection bias and limit the generalizability of the findings. Future longitudinal studies with larger, more diverse samples are needed to validate these results and provide further insights into the long-term consequences of welding arc exposure on color vision.

7. Source of Funding

Nil.

8. Conflict of Interest

Nil.

References

1. Peate WF. Work-related eye injuries and illnesses. *Am Fam Physician*. 2007;75(7):1017–22.
2. Pabley SA, Keeney HA. Welding processes and ocular hazards and new protective devices. *Indian J Ophthalmol*. 1984;32(5):347–9.
3. Heydarian S, Mahjoob M, Gholami A, Veysi S, Mohammadi M. Prevalence of color vision deficiency among arc welders. *J Optom*. 2017;10(2):130–4.
4. Voke J. Radiation effect on the eye - ocular effect of ultraviolet radiation. *Optom Today*. 1999;8:30–5.
5. Van Kuijk F. Effects of ultraviolet light on the eye: role of protective glasses. *Environ Health Perspect*. 1991;96:177–84.
6. Young RW. the family of sunlight related eye disease. *Optom Vis Sci*. 1994;71(2):125–44.
7. Okuno T, Ojima J, Saito H. Ultraviolet radiation emitted by CO(2) arc welding. *Ann Occup Hyg*. 2001;45(7):597–601.
8. Kocur I, Resnikoff S. Visual impairment and blindness in Europe and their prevention. *Br J Ophthalmol*. 2002;86(7):716–22.
9. Turner PL, Mainster MA. Circadian photoreception: ageing and the eye's important role in systemic health. *Br J Ophthalmol*. 2008;92(11):1439–44.
10. Joseph N, Venkatesh V, Akash SK, Hegde S, Moras E, Shenoy NP. Occupation Hazards - Pattern, Awareness and Preventive Measures

among Welders from an Unorganized Sector in India. *J Clin Diagn Res*. 2017;11(5):23–8.
11. Li XH, Wu CX, Hu Y, Liu XD. Comparative analysis on occupational hazards of three welding operations. *Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi*. 2022;40(4):288–91.
12. Chauhan A, Anand T, Kishore J, Danielsen TE, Ingle GK. Occupational hazard exposure and general health profile of welders in rural Delhi. *Indian J Occup Environ Med*. 2014;18(1):21–6.
13. Emmet EA, Buncher CR, Suskind RB, Jr KR. Skin and Eye Diseases Among Arc Welders and Those Exposed to Welding Operations. *J Occup Med*. 1981;23(2):85–90.
14. Mergler D, Huel G, Bowler R, Iregren A, Bélanger S, Baldwin M, et al. Nervous system dysfunction among workers with long-term exposure to manganese. *Environ Res*. 1994;64(2):151–80.
15. Gupta MN, Singh H. . In: Ocular effects and visual performance in welders. Bombay, India: Central Labor Institute; 1968.
16. Tenkate TD. Optical radiation hazards of welding arcs. *Rev Environ Health*. 1998;13(3):131–46.
17. Chou BR, Cullen AP. Ocular hazards of industrial spot welding. *Optom Vis Sci*. 1996;73(6):424–7.
18. Color vision problems become more common with age, study shows; 2014. Available from: https://www.sciencedaily.com/releases/2014/02/140220102614.htm.
19. Ishihara K, Ishihara S, Nagamachi M, Hiramatsu S, Osaki H. Age-related decline in color perception and difficulties with daily activities-measurement, questionnaire, optical and computer-graphics simulation studies. *Int J Ind Ergon*. 2001;28(3-4):153–63.
20. Joseph N, Venkatesh V, Akash SK, Hegde S, Moras E, Shenoy NP. Occupation Hazards - Pattern, Awareness and Preventive Measures among Welders from an Unorganized Sector in India. *J Clin Diagn Res*. 2017;11(5):23–8.
21. Sabitu K, Iliyasu Z, Dauda MM. Awareness of occupational hazards and utilization of safety measures among welders in Kaduna metropolis, northern Nigeria. *Ann Afr Med*. 2009;8(1):46–51.

Author biography

Asma Jabeen, Senior Resident https://orcid.org/0000-0002-6318-4359

Shazia Qayum, Assistant Professor

Cite this article: Jabeen A, Qayum S. Dyschromatopsia due to welding arcs: An underestimated occupational injury. *Indian J Clin Exp Ophthalmol* 2024;10(3):593-597.