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Original Article

Investigation of Color Vision and Contrast Sensitivity Defects in Textile Industry Workers

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ABSTRACT

Background: Industrial exposure to chemicals is a significant health concern, particularly within the textile industry where workers are in regular contact with potentially harmful substances. The retina, with its photoreceptor cells responsible for color vision and contrast sensitivity, is especially susceptible to damage from such exposure.

Objective: This study aims to assess the impact of chemical exposure on the color vision and contrast sensitivity of workers in the Five Star Textile Industry, drawing comparisons with previous research to better understand the occupational risks and requisite protective measures.

Methods: A cross-sectional, descriptive study was conducted on 100 workers with an age range of 20-50 years, examining 200 eyes. The research took place from January to June 2023, employing the Pelli-Robson chart and D-15 test for evaluating contrast sensitivity and color vision, respectively. Data were analyzed using the Pearson Chi-Square test and SPSS version 25.

Results: The study found a Pearson Chi-Square value of 31.4 for color vision in the right eye and 25.7 in the left, with a significance of 0.000 for both. Contrast sensitivity tests revealed a Pearson Chi-Square value of 44.2 for both eyes, with significance remaining at 0.000, indicating a strong correlation between chemical exposure and visual impairment.

Conclusion: The findings suggest a significant relationship between prolonged chemical exposure and visual function decline among textile workers, underlining the necessity for enhanced occupational health protocols and regular vision screening.

Keywords: Color Vision Deficiency, Contrast Sensitivity, Occupational Exposure, Textile Industry, Visual Health, Industrial Chemicals, Photoreceptor Cells, SPSS Analysis, Occupational Health and Safety, Vision Screening.

INTRODUCTION

Color vision represents the perceptual phenomenon originating within the human brain, activated by the absorption of light by photoreceptors situated in the retina of the eye(1). This perception is rooted in the trichromatic nature of human vision, enabling the identification and differentiation of colors through the integration of three primary colors: blue, green, and red(2,3). The retina, being the most sensitive layer of the eye, houses photoreceptor cells known as rods and cones. While cones are pivotal for color perception, rods facilitate vision in black and white. Upon activation, these photoreceptors relay signals through retinal neurons, progressing into the optic nerve fibers and ultimately reaching the cerebral cortex(4,5).

Dichotomizing color vision defects into congenital and acquired categories highlights their distinct etiologies. Congenital defects, primarily characterized by anomalies in the photo-pigment receptor cells, manifest uniformly in both eyes and typically affect red and green perception. In contrast, acquired defects, resulting from injuries, medication side effects, or chemical exposure, present variably between eyes and predominantly impair blue and yellow perception. Such defects are notably critical in professions requiring precise color discernment, including those in the textile, garment, and paint industries, as well as in fields such as tailoring, medical sciences, commercial driving, jewelry, interior designing, photography, and the armed forces(6,7).

Exposure to industrial chemicals like styrene, toluene, tetrachloroethylene, n-hexane, carbondisulfide, perchlorethylene, and benzene has been identified as a causative factor for color vision impairment. Beyond color perception, contrast sensitivity (CS)—

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the ability to discern between visible and indiscernible lines—is a crucial aspect of visual function. This sensitivity, essential for recognizing detail, relies on the ability to detect luminance differences within a visual field, a capability more pronounced in rods than in cones(8,9,10,11). Solvent exposure, notably to substances like benzene and toluene, is directly linked to diminished achromatic contrast sensitivity across all spatial frequencies, attributed to the lipo-soluble nature of these chemicals inducing widespread neural changes in the central nervous system(12).

This study hypothesizes that visual function declines are associated with occupational exposure to harmful chemicals, potentially leading to significant nervous system damage over time(1). Conditions impacting contrast sensitivity include amblyopia, neuro-ophthalmology issues, retinal diseases, and anterior segment diseases. By employing contrast sensitivity testing, it is possible to diagnose pathologies at an early stage, even before visual acuity is compromised, thereby uncovering central visual defects not detectable through traditional Snellen Visual acuity testing(13,14). In light of these considerations, the present investigation aims to assess color vision and contrast sensitivity among factory workers in the Five Star Textile industry, who are routinely exposed to a variety of chemicals during their work hours. This exploration into the occupational hazards faced by textile industry workers underscores the necessity of comprehensive visual function screening to preemptively identify and mitigate the adverse effects of chemical exposure on visual health.

MATERIAL AND METHODS

This study was undertaken at the Five Star Textile Industry in Faisalabad over a six-month period from January to June 2023. It encompassed a sample size of 200 eyes from 100 individuals, with ages ranging between 20 to 50 years. Employing a descriptive cross-sectional design and a convenience sampling method, the investigation aimed to evaluate color vision and contrast sensitivity among workers exposed to various chemicals in their workplace. Participants were recruited from diverse departments within the industry, including the sampling department, rotary and engraving, rotary and designing, exposing department, bleaching department, finishing department, washing department, and welding department.

Prior to data collection, informed consent was obtained from all participants who were willing to engage in the study. This process was conducted in accordance with the ethical guidelines stipulated in the Declaration of Helsinki to ensure the ethical treatment of all participants. The consent form outlined the study's objectives, potential risks, and confidentiality protocols regarding the handling of personal and medical information. Following consent, a comprehensive history was taken from each participant, covering personal, ocular, medical, and work-related aspects. This history aimed to identify factors that could potentially influence color perception and contrast sensitivity, including exposure to workplace chemicals. The assessment began with a personal history, including the participant's name, age, residence, and any chief complaints, to establish a rapport and encourage open communication.

Ocular history focused on identifying any visual discomfort experienced during work hours, such as irritation, burning sensation, use of prescription glasses, or any history of trauma or surgery. Medical history aimed to uncover any systemic pathologies, which would necessitate exclusion from the study. A detailed account of working hours and exposure levels was also obtained to evaluate the potential impact on visual function. The physical examination included an assessment of the anterior segment of the eye to identify any ocular pathology, examining the ocular adnexa, including lids, lashes, cornea, conjunctiva, and sclera.

Visual acuity was measured for each eye using the LogMar chart at a distance of 4 meters. Contrast sensitivity was assessed using the Pelli-Robson chart at a distance of 1 meter, which subtends an angle of 3 degrees to the eye. The minimum contrast legible to the participant was recorded as the contrast sensitivity value. Color vision was evaluated using the D-15 test, designed to identify acquired color vision defects. The test was conducted under daylight conditions, facilitated by a 60, 75, or 100-watt bulb, with the participant seated 50 cm from the tray containing fifteen moveable caps. Monocular testing was performed for each eye, with the sequence of cap arrangement recorded on a score sheet.

Data collection was meticulously documented and analyzed using SPSS version 25 to ensure the accuracy and reliability of the results. The Chi-square test was employed to explore the association between chemical exposure, the lack of protective eyewear use, and the incidence of color vision defects and contrast sensitivity impairment. This comprehensive methodology underscores the study's commitment to rigor and adherence to ethical standards, providing a solid foundation for evaluating the visual health impacts of chemical exposure in the textile industry.

RESULTS

The results presented in Table 1 and Table 2, along with the radar chart, provide a detailed analysis of color vision and contrast sensitivity among the studied sample. In Table 1, we observe the statistical evaluation of color vision deficiencies for both the right eye (OD) and the left eye (OS). The Pearson Chi-Square Test yields values of 31.4 for the right eye and 25.7 for the left, with both having an asymptotic significance of less than 0.001 (0.000 for OD and 0.001 for OS), indicating a highly significant difference in color vision deficiencies likely not due to chance. The Likelihood Ratio and Linear by Linear Association further corroborate these findings, although specific p-values are not provided.

Similarly, in Table 2, the Contrast Sensitivity test results indicate a Pearson Chi-Square Test value of 44.2 for both eyes, signifying a substantial association between the workers' exposure to chemicals and their contrast sensitivity, with an asymptotic significance (2-sided) marked at 0.000 for both eyes. This demonstrates a conclusive deviation from the expected contrast sensitivity performance, with continuity correlation and likelihood ratios reinforcing the significance of these results.

Table 1: Results of Color Vision Testing for Right Eye (OD) and Left Eye (OS)

Statistical Test	Right Eye (OD)	Left Eye (OS)	Asymptotic Significance (2-Sided)
Pearson Chi-Square Test	31.4	25.7	0.000 (OD) / 0.001 (OS)
Likelihood Ratio	33.5	27.1	-
Linear by Linear Association	19.4	10.1	-

Table 2: Results of Contrast Sensitivity Testing for Right Eye (OD) and Left Eye (OS)

Statistical Test	Right Eye (OD)	Left Eye (OS)	Asymptotic Significance (2-Sided)
Pearson Chi-Square Test	44.2	44.2	0.000
Continuity Correlation	41.6	41.6	-
Likelihood Ratio	48.7	48.7	-

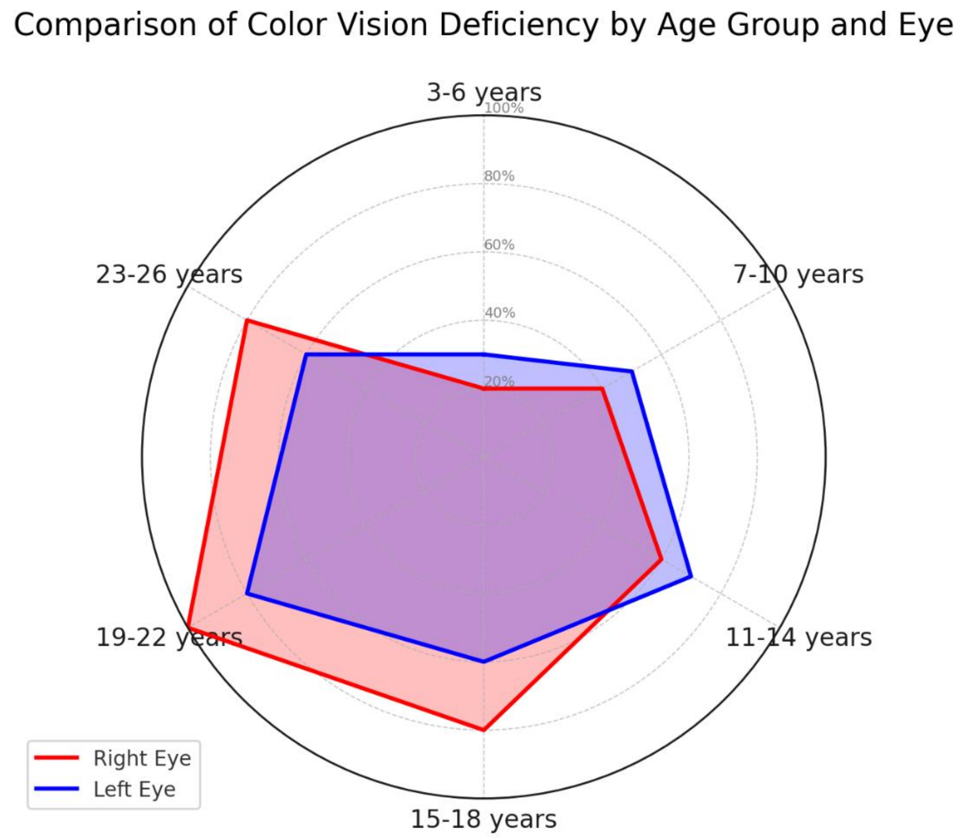

Figure 1 Comparison of Color Vision Deficiency by Age Group and Eye

Complementing the tables, the radar chart (Figure 1) conceptualizes the distribution of color vision deficiency types across different age groups. It visually represents the data on a polar coordinate system, where each axis corresponds to an age group, ranging from 3 to 26 years. The chart vividly illustrates a comprehensive comparison of the right and left eyes' data. The enclosed areas, defined by the plotted data points and filled with contrasting colors for each eye, enable a direct visual comparison across the age spectrum.

DISCUSSION

The present research delved into the complex interplay between occupational exposure to industrial chemicals and the subsequent effects on visual functions, namely color vision and contrast sensitivity. In the sensitive milieu of the retina, the photoreceptor cells, comprising cones and rods, play a pivotal role in color discrimination and vision in varying light conditions, respectively(3). It is well-established that chemical exposure can lead to alterations in retinal structures, as elucidated by Kollner's rules, which associate blue-yellow defects with anomalies in the choroid and retina, and red-green defects with afflictions of the optic nerve and visual pathway, manifesting a spectrum of symptoms contingent on the exposure duration(10,18-20).

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In a comparative examination, this study has aligned with previous research, such as the investigation involving gas station workers chronically exposed to organic solvents, where the duration of exposure was correlated with incremental visual impairment, including contrast sensitivity, color vision, and visual field deficits(15). Our research substantiated these findings, revealing significant visual deficits among workers in the Five Star Textile Industry, correlating these impairments with the chronicity of chemical exposure.

A similar pattern emerged in a study conducted within a car manufacturing setting, where a notable disparity in color vision deficiencies was observed between workers at old and new paint locations, indicating a potential link to the conditions and duration of chemical exposure within the workplace(16). The blue-yellow type of deficiency emerged as the most prevalent among those in prolonged contact with industrial paints, mirroring the findings of another study involving exposure to carbon disulfide in China. In this instance, despite the absence of fundus abnormalities, the exposed group demonstrated discernible deficits in green and blue color vision, implicating the chemicals as the likely culprits despite the use of standard ocular examination techniques(17).

Further supporting these observations, a study of welders highlighted a 15% incidence of color vision deficiency, predominantly of the blue-yellow type, with a noteworthy relationship between the extent of deficiency and the mean daily exposure to welding light(10). This resonates with our findings, which, through rigorous statistical analysis using SPSS and Chi-square tests, underline a significant relationship between color vision deficiencies and the duration of exposure to an array of solvents characteristic of the textile industry environment.

The convergence of results across diverse industrial settings underscores the vulnerability of visual functions to chemical exposures. However, a pivotal distinction emerged regarding contrast sensitivity, which, while affected by age, did not show a significant correlation with the duration of chemical exposure in our study. This suggests the potential for other confounding factors affecting contrast sensitivity, meriting further inquiry.

Our study, although robust in its findings, is not devoid of limitations. The cross-sectional design offers a snapshot in time, precluding the establishment of a causal relationship between chemical exposure and visual impairment. Additionally, the reliance on self-reported occupational histories could introduce recall bias, potentially skewing the association strength.

In the realm of occupational health, these insights necessitate a re-evaluation of protective measures for workers. The provision of appropriate protective eyewear and the implementation of regular visual function screening could serve as preventative measures. Moreover, longitudinal studies are warranted to ascertain the progression of visual deficits and to reinforce the causal linkages.

Conclusively, our research has added a significant tile to the mosaic of occupational health studies, affirming that chemical exposure in industrial environments like the Five Star Textile Industry has palpable ramifications on color vision and contrast sensitivity, with age emerging as a significant factor in contrast sensitivity impairment. These findings provide an impetus for enhanced protective strategies and health surveillance protocols to safeguard the visual health of workers against the backdrop of chemical exposure.

CONCLUSION

In conclusion, the study conducted among workers in the Five Star Textile Industry substantiates a significant correlation between chemical exposure and the impairment of color vision, with age-related decline observed in contrast sensitivity. These findings highlight the critical need for improved protective measures and regular vision screening in occupational settings to mitigate the adverse effects of industrial chemicals on workers' visual health, thereby enhancing overall human healthcare within such environments.

REFERENCES

1. Fattahi F, Khabazkhoob M, Jafarzadehpour E, Mirzajani A, Yekta A. Evaluation of contrast sensitivity and color vision in lead and zinc mine workers. Rom J Ophthalmol. 2020;64(1):43-9.

2. Campagna D, Mergler D, Huel G, Belanger S, Truchon G, Ostiguy C, et al. Visual dysfunction among styrene-exposed workers. Scandinavian journal of work, environment & health. 1995:382-90.

3. Bonilla-Silva E. Color-blind racism in pandemic times. Sociology of Race and Ethnicity. 2022;8(3):343-54.

4. Drew S. Anatomy And physiology of the eye, contrast, contrast sensitivity, luminance perception and psychophysics. Draft Report, Griffith University, Australia. 2005.

5. Zhao J, Davé SB, Wang J, Subramanian PS. Clinical color vision testing and correlation with visual function. American journal of ophthalmology. 2015;160(3):547-52. e1.

6. Hall J. Receptor and neural functions of retina. Guyton and Hall Textbook of Medical Physiology 11th ed Uttar Pradesh: Elsevier Publications. 2011:626-38.

7. Neitz J, Neitz M. The genetics of normal and defective color vision. Vision research. 2011;51(7):633-51.

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8. Rocha RJ, Silva FMC, Martins HBM, Nascimento SR, Oliveira MC, Souza GS, et al. Visual evaluation in workers occupationally exposed to cosmetics. Psychology & Neuroscience. 2021;14(3):343.

9. Saint-Amour D, Muckle G, Gagnon-Chauvin A, Rouget F, Monfort C, Michineau L, et al. Visual contrast sensitivity in school-age Guadeloupean children exposed to chlordecone. Neurotoxicology. 2020;78:195-201.

10. Costa TL, Barboni MTS, Moura ALdA, Bonci DMO, Gualtieri M, de Lima Silveira LC, et al. Long-term occupational exposure to organic solvents affects color vision, contrast sensitivity and visual fields. 2012.

11. Oliveira A, Campos Neto A, De Andrade M, De Medeiros P, Dos Santos N. Organic solvent exposure and contrast sensitivity: comparing men and women. Brazilian Journal of Medical and Biological Research. 2018;51:e6568.

12. Pelli DG, Bex P. Measuring contrast sensitivity. Vision research. 2013;90:10-4.

13. Heydarian S, Mahjoob M, Gholami A, Veysi S, Mohammadi M. Prevalence of color vision deficiency among arc welders. Journal of optometry. 2017;10(2):130-4.

14. Owsley C. Contrast sensitivity. Ophthalmology Clinics of North America. 2003;16(2):171-7.

15. Attarchi MS, Labbafinejad Y, Mohammadi S. Occupational exposure to different levels of mixed organic solvents and colour vision impairment. Neurotoxicology and teratology. 2010;32(5):558-62.

16. Muttray A, Wolff U, Jung D, Konietzko J. Blue-yellow deficiency in workers exposed to low concentrations of organic solvents. Occupational Health and Industrial Medicine. 1998;2(38):83.

17. Wang C, Tan X, Bi Y, Su Y, Yan J, Ma S, et al. Cross-sectional study of the ophthalmological effects of carbon disulfide in Chinese viscose workers. International journal of hygiene and environmental health. 2002;205(5):367-72.

18. Cole D, Narayanan S, Vickery S. Does leader disability status influence the operational performance of teams with individuals with disabilities? An empirical study in the apparel industry. Journal of Operations Management. 2024 Jan 8.

19. Silva V, Senevirathne T, Fareed N, Sandanayake T, Karunaratne I. Multi-Modal Defect Detection System for Single Color Fabrics in the Apparel Industry. In2023 8th International Conference on Information Technology Research (ICITR) 2023 Dec 7 (pp. 1-6). IEEE.

20. Alruwais N, Alabdulkreem E, Mahmood K, Marzouk R, Assiri M, Abdelmageed AA, Abdelbagi S, Drar S. Hybrid mutation moth flame optimization with deep learning-based smart fabric defect detection. Computers and Electrical Engineering. 2023 May 1;108:108706.