ORIGINAL ARTICLE

EVALUATION OF COLOUR VISION DEFECTS USING D-15 IN RELATION WITH IRIS COLOUR AND PUPIL SIZE; A CROSS-SECTIONAL STUDY

Muhammad Rashid[1], Ayesha Saleem[1], Muhammad Shaheer[2], Muhammad Moin[3], Ummara Rasheed[4], Asima Rafique[5]

ABSTRACT

Introduction: Colour of iris is associated with race and may show hereditary patterns. In this context it may be associated with colour vision defects and size of pupil. This study was conducted to determine whether variations in iris colour and pupil size were correlated with colour vision defects as measured by the D-15 test.

Material & Methods: A proforma based cross-sectional study was conducted at College of Ophthalmology and Allied Vision Sciences in Mayo Hospital, Lahore. Data was collected from September 2023 to December 2023. The study was approved by the Ethical review board of the College of Ophthalmology and Allied Vision Sciences. The sample size was 70 subjects, with the inclusion criteria being individuals aged 18 or older, having normal colour vision or colour vision deficiency, and able to read and understand D15 instructions. Exclusion criteria included those with a history of eye disease or injury, taking medication that could affect colour vision, or those unable to complete the D15 due to physical or cognitive limitations. Statistical significance was calculated using Chi-square test. P value<0.05 was considered significant.

Results: Brown iris colour was common (51.47%) with predominance in females. Pupil size in the range of 6.6-7.0mm was higher in females. Two patients had colour blindness with iris colour of brown and amber (P=0.613) and their pupil size was between 6.6mm to 7.5mm (0.047) depicting positive correlation.

Conclusion: Colour vision defects were not significantly influenced by iris colour; however, larger pupil sizes (6.6-7.5mm) showed a noteworthy correlation with these vision problems.

Keywords: Colour Vision, Colour Vision Defects, Pupil, Iris.

Authors' Declaration: The authors declared no conflict of interest and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed substantially to the planning of research, question designing, data collection, data analysis and write-up of the article.

Authors' Affiliation

[1]Optometrist, College of Ophthalmology and Allied Vision Sciences, Mayo Hospital, Lahore
[2]Associate Professor, King Edward Medical University, Lahore
[3]Professor, King Edward Medical University, Lahore
[4]Statistician, College of Ophthalmology and Allied Vision Sciences, Mayo Hospital, Lahore
[5]Senior Registrar, Sir Gangaram Hospital, Lahore

Corresponding Author

Muhammad Shaheer
Associate Professor
King Edward Medical University, Lahore
Email: mshaheer212@gmail.com

This article may be cited as: Rashid M, Saleem A, Shaheer M, Moin M, Rasheed U, Rafique A. Evaluation of colour vision defects using D-15 in relation with iris colour and pupil size; a cross-sectional study. Rehman J Health Sci. 2024;6(2). 124-128

Submitted: July 21, 2024 Revisions Submitted: Dec 03, 2024 Accepted: Dec 24, 2024

INTRODUCTION

Colour vision is a marvel of neural interpretation, where our brain translates light's energy and wavelengths into the vibrant world we perceive. This fascinating process remains a mystery, a puzzle of how the brain dissects and fuses these properties to craft our rich perception of colour.[1] The intricacies of this physiology emerge through the study of individual neurons, shedding light on this complex symphony.[2]

In our daily lives, colour serves diverse purposes, categorizing tasks into comparative, connotative, and denotative realms. From matching textiles to decoding

traffic signals, colours play pivotal roles, often carrying specific meanings that guide our actions and interpretations. They become the tools for deciphering complexities, distinguishing objects, and organizing the visual chaos around us.[3]

Colour vision disorders, categorized into acquired and congenital, showcase varied limitations in perceiving specific wavelengths of light. While congenital deficiencies receive more attention, affecting a notable percentage of males and a smaller fraction of females, acquired disorders remain less explored.[4] Mutations in genes like OPN1LW illustrate how specific alterations disrupt red-green discrimination, impacting activities involving colour-coded information.[4]

Diagnostic tools like the D-15 test, previously known as the Farnsworth-Munsell 100 Hue Test, have long been the cornerstone for identifying colour vision deficiencies. However, recent research casts doubt on their reliability, particularly in clinical settings, challenging the efficacy of these assessment methods.[5]

Recent studies have illuminated how the spectral composition of light sources influences colour perception, notably affecting pupil dynamics. Different light sources wield unique impacts on pupils, ultimately shaping our perception of colours.[6] Investigations into illumination variations reveal their direct influence on pupil size, consequently influencing our colour perception, especially within controlled laboratory conditions. The dynamic nature of pupil responses under different illumination conditions reflects the intricate interplay between visual processing and the stimuli perceived through L, M, and S cone photoreceptors.[7]

Extended exposure to light prompts sustained pupil constriction, orchestrated by inner retinal cells expressing melanopsin (ipRGCs).[8] This phenomenon plays a pivotal role in conditions like achromatopsia, exhibiting symptoms such as photophobia, nystagmus, compromised visual acuity, and complete colour blindness[9].

In this intricate symphony of perception, colours are not merely pigments but narrators of a vibrant tale, seamlessly integrating with the neural dance, guiding our understanding of the world's hues and nuances[10]. They paint the canvas of our experiences, shaping how we navigate and interpret the kaleidoscope of life.[11] Colour of iris is associated with race and may show hereditary patterns. In this context it may be associated with colour vision defects and size of pupil. This study was conducted to determine whether variations in iris colour and pupil size were correlated with colour vision defects as measured by the D-15 test.

MATERIAL AND METHODS

A proforma based cross sectional study was conducted at College of Ophthalmology and Allied Vision Sciences/Mayo Hospital, Lahore, from September 2023 to December 2023. The study was approved by the Ethical review board of the college of Ophthalmology and Allied Vision Sciences vide no.1624/23.

The sample size was 70 subjects and was calculated by taking power of test 95%, level of significance 5% and standard deviation 1.43.[12] The inclusion criteria being individuals aged 18 or older, having normal colour vision or colour vision deficiency, and able to read and understand D-15 instructions. Exclusion criteria included those with a history of eye disease or injury, taking medication that could affect colour vision, or those unable to complete the D-15 due to physical or cognitive limitations. Colour vision testing was done by asking the subject to complete D-15 test which required arranging different colour spots in increasing order while pupillometry was done under normal photopic conditions with the help of a transparent scale (ruler). Data was entered and analysed in SPSS version 26. Iris colour and gender are presented as frequency and percentages. Statistical significance (Correlation) was calculated using Chi-square test. P value<0.05 was considered significant.

RESULTS

The study consisted of 70 participants, predominantly male (54.3%), with 38 males

and 32 females, aged between 18 and 40 years. Regarding colour vision defects, a minimal occurrence was noted across iris colours, with few instances in brown and amber. However, statistical analyses didn't show a significant correlation between iris colour and colour vision defects (P-value > 0.05). On the other hand, larger pupil sizes, particularly in the 6.6-7.5mm range, displayed a noteworthy association with colour vision defects. Spearman's correlation analysis highlighted a significant link between pupil size and colour vision defects, suggesting a potential relationship worth exploring further. Majority of the included population were with brown eyes (see table-1-4 for further details).

Table 1: Iris Colour and Gender

Iris colour	Brown	Amber	Hazel	Grey	Green
Male	13	8	9	6	2
Female	23	5	2	1	1
Total	36(51.47%)	13(18.57%)	11(15.71%)	07(10%)	03(4.29%)

Table 2: Pupil Size and Gender

Pupil size (mm)	3-3.5	3.6-4	4.1-4.5	4.6-5	5.1-5.5	5.6-6	6.1-6.5	6.6-7	7.1-7.5	7.6-8
Male	1	0	2	2	5	13	10	3	1	2
Female	0	0	0	1	3	11	7	8	1	0

Table 3: Role of Iris Colour in Colour Vision Defect

Iris colour	Brown	Amber	Hazel	Grey	Green	P-value
Colour Vision Defect	1	1	0	0	0	0.613

Table 4: Role of Pupil Size in Colour Vision Defects

Pupil size (mm)	3-3.5	3.6-4	4.1-4.5	4.6-5	5.1-5.5	5.6-6	6.1-6.5	6.6-7	7.1-7.5	7.6-8	P-value
Colour Vision Defect	0	0	0	0	0	0	0	1	1	0	0.047

DISCUSSION

In current study, Brown iris colour was common (51.47%) with predominance in females. Pupil size in the range of 6.6-7.0mm was higher in females. Two patients had colour blindness with iris colour of brown and amber (p=0.613) and their pupil size was between 6.6mm to 7.5mm (0.047) depicting positive correlation.

Congenital colour vision deficiency is a common inherited disorder that affects up to 8% of males and 0.5% of females, often resulting in visual impairment. It is currently untreated, and recent molecular genetics advancements have opened the possibility of gene therapy.[13] Acquired colour vision deficiency is caused by various ocular, neurologic, or systemic diseases, affecting colour vision from ocular media to visual cortex pathology. Traditionally, it is separate from congenital deficiency, but genetic data suggests overlap.[14]

Several studies have examined the relationship between iris colour, ethnicity, macular pigment optical density (MPOD), and hue discrimination. Garakani R and associates conducted a study involving 30 subjects with normal colour vision who completed MPOD testing and Farnsworth-Munsell 100 hue (FM100) testing. Results showed that MPOD was associated with iris colour and ethnicity, but not with iris

reflectance, which may be a better indicator of ocular pigmentation.[12, 15] Mahju T and colleagues conducted a study on Iris Colour and Visual Function, aiming to determine which iris colours significantly affect visual functions in 75 individuals with different iris colours. The results showed that 100% of the subjects had 6/6 visual acuity, 12/12 colour vision on the Isihara colour vision chart, 1.25% contrast sensitivity on the lea number contrast sensitivity chart, glare visual acuity between 6/12-6/18, and full confrontation visual field.[16] These results do not agree with our study results which showed negative correlation of iris colour with colour blindness (p=613).

Another study by Dain SJ and associates investigated the Farnsworth-Munsell 100 Hue test performance in three groups with different macular pigmentation and age ranges. The blue-eyed group performed better than the Asian group and brown-eyed subjects, with the difference in pupil size between the blue-eyed and brown-eyed groups being significant. The conclusion is that pupil size, not just macular pigment, may have a significant influence on colour vision performance in a young, healthy population.[17] This influence of pupil size was also depicted by positive correlation with colour vison defects (0.04) in our study.

Schmidt GW and colleagues evaluated the relationship between ablation diameter, pupil size, and visual function after laser in situ keratomileusis (LASIK) at the University of California, San Francisco. Results showed that mesopic and scotopic pupil diameter had no significant association with RQL satisfaction scores. However, patients reported less worry, more satisfaction, clearer vision, and better far vision as uncorrected visual acuity improved. Larger pupil diameter was not significantly associated with postoperative satisfaction and visual function, but the significant associations between pupil size and uncorrected visual acuity validated the RQL instrument and confirmed post-operative BCVA as a strong predictor of patient satisfaction after refractive surgery.[18, 19]

A study by Mathôt S et al reveals that pupil size, when manipulated through peripheral brightness, has different effects on discrimination of fine stimuli in central vision and detection of faint stimuli in peripheral vision. Small pupils improve discrimination performance for very small stimuli, while large pupils improve detection performance. The data set presented in this study provides valuable insights into the distribution of iris colours, pupil sizes, and colour vision defects among individuals. While there is no strong evidence to reject the null hypothesis that there's no relationship between iris colour and colour vision defects, the data suggests a potential association between larger pupil sizes and colour vision defects. Further research and investigation are needed to fully understand these findings and their implications for understanding eye health.[7, 20] This was a single center study with a small sample size. The study reveals a link between larger pupils and colour vision issues, highlighting the need for larger, diverse studies. It recommends using advanced methods and longitudinal assessments for deeper insights and diagnostic implications in ocular health.

CONCLUSION

This Research found no significant correlation between colour vision defects and iris colour. However, bigger pupil sizes (6.6-7.5 mm) showed a possible association with colour vision impairments.

REFERENCES

1. Chakrabarti S. Psychosocial aspects of colour vision deficiency: Implications for a career in medicine. Natl Med J India. 2018;31(2).

2. Wool LE, Crook JD, Troy JB, Packer OS, Zaidi Q, Dacey DM. Nonselective wiring accounts for red-green opponency in midget ganglion cells of the primate retina.J Neurosci . 2018;38 (6):1520-1540

3. Carroll J, Conway BR. Colour vision. Handbook of Clinical Neurology.Handb Clin Neurol. 2021; 178:131-53.

4. Jha RK, Khadka S, Gautam Y, Bade M, Jha MK, Nepal O. Prevalence of Colour Blindness in Undergraduates of Kathmandu

University. J Nepal Med Assoc. 2018;56(214):900-903.
5. Zarazaga AF, Vásquez JG, Royo VP. Review of the main colour vision clinical assessment tests. Archivos de la Sociedad Española de Oftalmología.Arch Soc Esp Oftalmol.2019;94(1):25-32.
6. Good GW, Schepler A, Nichols JJ. The reliability of the Lanthony Desaturated D-15 tests. Optom Vis Sci. 2005;82(12):1054-9.
7. Suzuki Y, Minami T, Laeng B, Nakauchi S. Colourful glares: Effects of colours on brightness illusions measured with pupillometry. Acta Psychol. 2019; 198:102882.
8. Mathôt S, Ivanov Y. The effect of pupil size and peripheral brightness on detection and discrimination performance. Peer J. 2019; 7:8220.
9. Kret ME, Sjak-Shie EE. Preprocessing pupil size data: Guidelines and code.Behav Res Meth. 2019; 51:1336-42
10. Khan AO. Phenotypes and genotypes underlying paradoxical pupillary reactions in children. J Am Assoc Peadtr Ophth Strab. 2022;26(4):205-7.
11. Zele AJ, Adhikari P, Cao D, Feigl B. Melanopsin and cone photoreceptor inputs to the afferent pupil light response. Front Neurol. 2019;10:529.
12. Marié S, Montés-Micó R, Martínez-Albert N, García-Marqués JV, Cerviño A. Evaluation of physiological parameters on discomfort glare thresholds using lumiz 100 tool. Transl Vis Sci Technol. 2021;10(8):28-.
13. Garakani R, Ng JS. Associations between macular pigment, iris colour and reflectance, ethnicity, and colour vision: an observational study. Plos one. 2019;14(8):0220940.
14. El Moussawi Z, Boueiri M, Al-Haddad C. Gene therapy in colour vision deficiency: a review. Int Ophthalmol. 2021;41: 1917-27.
15. Stoianov M, de Oliveira MS, dos Santos Ribeiro Silva MCL, Ferreira MH, de Oliveira Marques I, Gualtieri M. The impacts of abnormal colour vision on people's life: an integrative review. Qual Life Res. 2019;28: 855-62.
16. Sun H-P, Lin Y, Pan C-W. Iris colour and associated pathological ocular complications: a review of epidemiologic studies. Int J Ophthalmol. 2014;7(5):872.
17. Mahju T, Qadeer S. Iris Colour and Visual Function. Ophthalmol Pak. 2015;5(02):28-31.
18. Dain SJ, Cassimaty VT, Psarakis DT. Differences in FM100-Hue test performance related to iris colour may be due to pupil size as well as presumed amounts of macular pigmentation.Clin Exp Optom. 2004;87(4-5):322-5.
19. Schmidt GW, Yoon M, McGwin G, Lee PP, McLeod SD. Evaluation of the relationship between ablation diameter, pupil size, and visual function with vision-specific quality-of-life measures after laser in situ keratomileusis. Arch Ophthalmol. 2007;125(8):1037-42.
20. Wang Q, Stoakes IM, Moshirfar M, Harvey DH, Hoopes PC. Assessment of Pupil Size and Angle Kappa in Refractive Surgery. Cureus. 2023;15(8).