(International Print/Online Journal)

SJIF IMPACT FACTOR: 5.565
PUBMED-National Library of Medicine ID-101739732

ISSN (Print): 2209-2870
ISSN (Online): 2209-2862

International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume 5, Issue 1, Page No: 1256-1263
January-February 2022

IJMSCR

Assessment of Color Vision Defects Using Farnsworth Munsell D15 Panel Among Children In Kashmir Valley

Dr. Ifrah Shafat Kitab, Dr Afroz Khan, Dr Afshan Kounser, Dr Sidra Javaid Thakur, Dr Poonam Sharma
Gousia Colony, Bemina, Srinagar, J&K, India. 190018

***Corresponding Author:**
Dr. Ifrah Shafat Kitab
Gousia Colony, Bemina, Srinagar, J&K, India. 190018

Type of Publication: Original Research Paper
Conflicts of Interest: Nil

Abstract

Context: Color vision deficiency (CVD) is commonly seen in Caucasians with a prevalence of about 8% in males and 0.4% in females. It is predominant in Muslim populations owing to consanguineous marriages. Farnsworth Munsell D-15 test is a hue discrimination test used for classifying the type of CVD. However, its efficacy as a screening tool has not garnered much interest.

Aim: This study was conducted to determine prevalence of CVD in Kashmir valley and to determine the relevance of Farnsworth Munsell D-15 panel as a screening tool.

Settings and Design: This study was a cross-sectional study conducted in 20 schools of district Srinagar selected randomly using cluster sampling methodology

Methods And Materials: Assessment of color vision was done in school children aged 11-14 years using Ishihara plates followed by Farnsworth Munsell D-15 panel. The classification of type of CVD was also done into protan, deutan and tritan defects.

Statistical Analysis Used: Statistical analysis was done using OpenEpi software. Discrete variables were assessed using Chi-square test and a p-value < 0.05 was taken as significant.

Results: The prevalence of CVD by Ishihara test was 7.42% in males and 1.3% in females while it was 6.23% and 0.97% as determined by D-15 panel. Majority (70.83%) of cases were suffering from deutan defects and remaining (29.17%) were had protan defects, while none had tritan defect.

Conclusion: Ishihara test and Farnsworth Munsell D15 panel were both handy tools in screening of congenital CVD. Farnsworth D15 panel was better at classifying the type of CVD.

Keywords: Color vision deficiency, Kashmir, Farnsworth Munsell D-15 panel

Introduction

Color vision is the ability to differentiate a light stimulus as a function of its wavelength. The ability to perceive the differences in these waves varies from person to person and forms the basis of one's color vision. Retinal cells in the parvocellular pathway are responsible for fine and chromatic stimuli, while cells of the magnocellular pathway are responsible for moving and achromatic stimuli.[1]

Color can be described in terms of hue (determined by wavelength) and saturation (amount of white light mixed). Those with color vision deficiencies see fewer hues than normal. Color blindness is the commonly used term for color vision deficiency (CVD) and is the inability or decreased ability to perceive color differences.

The defect of color vision perception is classified based on the number of functional photopigments as follows: achromatism (no functional photopigments), monochromatism (single functional and two

defective photopigments) and dichromatism (two functional and one defective photopigment). Anomalous Trichromacy is a relatively milder form of colour vision defect and the most common category of color blindness. This is due to decreased spectral sensitivity of cones. There are 3 forms of Anomalous trichromacy- protanomaly, deuteranomaly and tritanomaly; representing a decreased sensitivity to red, green and blue colors respectively.

Normal color vision is important for our daily routine work, such as to recognize the traffic signals or to build career in several professions like aviation, military, driving, electrical engineers, chemists, etc.[2] Color vision deficient individuals are usually unaware of their disability.

Color Vision Tests:

There is a large inventory of color vision tests designed to serve various purposes.

Screening test: Identifies subjects with normal and abnormal colour vision;

Grading test: Estimates severity of colour deficiency;

Classifying test: Diagnosing the type and severity of colour deficiency;

Vocational test: Identifies color-matching ability, hue discrimination and colour recognition.

Pseudoisochromatic tests are a commonly employed method of screening for color vision deficiency. Pseudoisochromatic plates are hand held devices for detection of color blindness and are based on discrimination of number or shapes against a potentially confusing background. The commonly employed tests include the Ishihara Plates, American Optical Hardy-Rand-Rittler Plates, Standard Pseudoisochromatic plates and City University test.

Arrangement Tests: These include Farnsworth-Munsell 100 hue test, Farnsworth-Munsell Dichotomous D-15 or Panel D-15 test, Lanthony Desaturated D-15 and Adams Desaturated D-15.

The Farnsworth-Munsell D-15 test is a hue discrimination test. It is a shortened version of the dichotomous test described by Farnsworth in 1943. The originally devised test had 20 colors while the D-15 version consists of one reference cap and 15 moveable colored caps that form a hue circle within the Commission Internationale l'Eclairage (CIE) diagram. It subtends 1.5 degree at 50 cm test distance. The 15 movable caps have Munsell value (relative lightness of a color) of 5 and Chroma (color saturation) of 4.[3] The color caps are to be arranged in an order that the color next to the reference cap is the closest in color and so on for all other caps. A time of one to two minutes should be allowed to complete the task. Next, the numbers on the undersides of these caps are exposed and noted. These numbers can then be transferred to the circle of dots at the bottom of the score sheet, joining the numbers which are placed next to each other.

Though the Farnsworth D-15 test allows the differentiation of protan, deutan and tritan defects, it tends to miss minor defects in CVD and certain anomalous trichromats may pass the test.[4] Comprehending its efficacy as a screening tool has not garnered much interest in this part of the world.

Color blindness is prevalent in Caucasian populations with a prevalence of about 8% in males and 0.4% in females.[5] A recent Muslim population based study from India reported a prevalence of 8.13% in males and 1.69% in females.[6]

In Muslims, where consanguineous marriages are common, genetic disorders are more prevalent. Therefore, this study holds great relevance for Kashmiri population, which is predominantly Muslim.

This study was undertaken to determine the prevalence and type of CVD prevalent in Kashmir valley and understand the relevance of Farnsworth Munsell D-15 panel as a screening tool in our setup.

Materials and Methods

This study was a cross-sectional study conducted in 20 schools of district Srinagar selected randomly using cluster sampling methodology. The list of eligible schools was obtained from the office of Chief Education Officer, Srinagar. All the schools in district Srinagar were line listed along with their total student roll and 20 schools were randomly selected based on the probability proportional to size (PPS) method.

Study population

In a selected school, all children aged 11-14 years were interviewed and examined after permission

Volume 5, Issue 1; January-February 2022; Page No 1256-1263

from their respective principals and obtaining an informed consent from their guardians. Children aged 11-14 years were selected for the purpose of this study in accordance with the recommendations of the joint working party of British pediatric association[7] as children in this age can aptly follow instructions and properly undertake the assessment tests for color vision.

Inclusion criteria: All students aged 11-14 years, male as well as female, were included in the study.

Exclusion criteria: Students with history of any significant ocular or craniocerebral trauma; history of any drug intake known to affect color vision; children with degenerative myopia; and children with previous retinal or optic nerve disease were excluded from the study.

Ethical clearance was sought and obtained from the institutional ethical committee before undertaking the study.

Detailed ocular examination was done in all patients using a slit lamp biomicroscope.

Visual acuity was assessed with internally illuminated Snellen chart at a distance of six meters. Subjective as well as objective assessment of refractive errors was done using trial lens set and Hiene Beta 200 streak retinoscope respectively. Evaluation of fundus abnormalities was done with the help of a direct ophthalmoscope (Hiene beta 200 3.5V).

Next, color vision testing was done using 38 plate Ishihara chart. The test was repeated for confirmation in case any child faltered or made a mistake.

This was followed by assessment of color vision deficit as well as type of defect using Farnsworth-Munsell D15 panel. The children were instructed to arrange the Farnsworth D-15 color caps from 50cm distance in an order that the color next to the reference cap is the closest in color and so on for all other caps (Figure 1). This test panel was presented to right eye first and then to the left eye, under natural daylight condition. The reversing of the order of two caps located closely together was considered a minor error. A minor error is not considered to have clinical relevance. A major error was considered if the line joining the two caps made a crossing across the circle[8], parallel to one of the three confusion axis. If two or more major crossings were made, then the color vision defect could be said to be relevant and orientation of the confusion loci, described by the crossings on the plot, was used to describe whether the color vision defect was protan, deutan or tritan. If there were two or more major crossings, it was considered to be an anomaly (deuteranomaly, protanomaly, tritanomaly). In case the number of major crossings exceeded 6, the defect was considered to be anopia (deuteranopia, protanopia, tritanopia). A single mid-test reversal is not considered as an error. If the confusion axis is located approximately between the deutan and tritan axes, the color vision defect is said to be monochromatic.[9]

Results

The study included a total of 645 children aged 11-14 years with 337 males (52.2%, n = 337/645) and 308 females (47.8%, n = 308/645), enrolled from 20 schools of district Srinagar.

Out of 645 students, 80.8% (n = 521/645) had no refractive error in either eye while the remaining 19.2% (n = 124/645) suffered from errors of refraction in one or both eyes. Out of these, 110 had refractive error in both eyes while the remaining 14 had unilateral affliction. The best corrected visual acuity was 6/6 for both eyes in all the cases. No abnormality was detected on slit lamp examination and direct ophthalmoscopy.

Assessment of color vision defects was done using 38 plate Ishihara test. Out of 645 students assessed, 29 students (4.5%, n = 29/645) were found to be suffering from color vision defects. These included 25 males and 4 females. These students made atleast 4 or more errors in the screening plates of Ishihara test. A total of 616 students made three or fewer errors which was considered to be normal. The number of errors made by each student are presented in figure 2.

The prevalence of CVD as assessed by Ishihara test was found to be 7.42% (n = 25/337) among males while the corresponding figure in females was calculated as 1.3% (n = 4/308). The gender specific occurrence of CVD versus normal vision is presented in figure 3 in the form of a bar chart. The difference in gender specific prevalence of color vision deficit (CVD) was found to be statistically significant using student's t-test (p-value = 0.0002). (Table 1)

Volume 5, Issue 1; January-February 2022; Page No 1256-1263

The Ishihara plates were also used to differentiate protan and deutan defects in cases with CVD. Out of the 29 cases diagnosed with CVD using Ishihara plates, only 19 cases (65.52%, n = 19/29) could be further sub-classified as protan or deutan while as the remaining 10 (34.48%, n = 10/29) could not be clearly categorized into one of the two groups. (Table 2)

The assessment of color vision deficiency was also done using Farnsworth Munsell D15 panel in all students, irrespective of the results of Ishihara test. Out of 645 students, 125 (19.38%) had one major crossing but this is considered to be normal. The number of major crossings encountered in the students is presented in figure 4.

Clinically relevant major crossings (two or more) were seen in 24 cases, thus indicating the overall prevalence of color vision defect as 3.72% (n = 24/645). This included 21 males and 3 females with a gender specific prevalence of 6.23% (n = 21/337) and 0.97% (n = 3/308) respectively. The difference in gender specific prevalence of CVD as determined by D15 panel was also found to be statistically significant using student's t-test (p-value < 0.001). (Table 3)

The determination of type of CVD was done using the D15 panel and documented 17 students (70.83%, n = 17/24) to be suffering from deutan defects while only 7 students (29.17%, n = 7/24) were suffering from protan defects. None of the students were found to be suffering from tritan defects. Further classification of type of defect and their prevalence in each gender is presented in table 4.

The ability of Ishihara test to pick up color vision deficiency and detect type of CVD was compared with that of Farnsworth Munsell D15 panel. Twenty nine students were classified as having CVD using Ishihara chart but five of these passed D15 panel and only 24 were classified as CVD based on this. On the other hand, all the patients who failed at D15 panel were likely to falter with Ishihara plates as well. Using Ishihara plates as the standard, the sensitivity and specificity of D15 panel was calculated as 82.76% (n = 24/29) and 99.19% (n = 616/621) respectively.

With respect to the ability to distinguish the type of CVD, 10 cases (34.48%) could not be classified into a particular type (protan or deutan) when using Ishihara plates. As D15 panel is the standard for classification of CVD, the ability of Ishihara plates to classify type of CVD was compared with it. Out of the 17 cases labelled as having deutan defects using the D15 panel, 15 cases were classified as deutans using Ishihara plates. On the contrary, one case classified as deutan using Ishihara plates passed the D15 panel and was categorized as having normal color vision. Similarly, out of the 7 cases confirmed as suffering from protan defects using D15 panel, only 3 were picked up as protan using Ishihara plates. Overall, D15 plates were more efficient in classification of type of defect as compared to Ishihara plates. Also, the efficacy of D15 panel was more pronounced in picking up protan defects than deutan defects when compared to Ishihara plates. The significant superiority of D15 in picking up protan defects over deutan defects when compared to Ishihara test had a statistical relevance (p-value = 0.019). (Table 5)

None of the students suffering from CVD were aware of their deficiency. However, a number of students (54.17%, n = 13/24) reported having faced some sort of difficulty or confusion regarding colors, atleast once in their lifetime; often during discussions regarding colors among peer groups.

Discussion

In our study, the prevalence CVD using Ishihara test was 4.5% while the corresponding value determined using Farnsworth Munsell D15 panel was 3.72%. Our findings were similar to those reported in literature from various parts of India which report the prevalence of CVD ranging from 2.1% to 4.7%.[10,11,12,13] This prevalence of CVD conformed most closely to that reported by Masood et al in their study which reported an overall prevalence of 4.7%.[11] This was expected as Ishihara test is known to have a higher sensitivity as compared to the D15 panel in the detection of color vision deficiency.[10] Normal individuals with poor discrimination may fail the Ishihara test at times. The relative insensitivity of D15 panel in detecting mildly affected individuals is an asset in judging the practical significance of mild color vision deficiency. Individuals who are detected as having CVD on Ishihara test but pass the D15 panel do not have color discrimination problems

Volume 5, Issue 1; January-February 2022; Page No 1256-1263

under most circumstance and are suitable for most jobs.[14]

Color vision deficiency was found to occur more commonly in males as compared to females using Ishihara charts (7.42% vs 1.3%) as well as Farnsworth Munsell D15 panel (6.23% vs 0.97%). This finding has been reported in literature[10,11,12,13,15] and is consistent with the fact that red-green color vision deficiency has predominantly an X-linked recessive inheritance. As males are hemizygous for most genes on X-chromosome, so a single affected allele is sufficient to produce red-green CVD in males while a similar setup in females would lead to a carrier state only. Females are affected with color blindness only when they are homozygous for this allele on X-chromosome.

The type of CVD assessed using diagnostic plates of the 38 plate Ishihara test determined deutan defects to be more common than protan defects. It has been commonly mentioned in literature than green color receptors are affected more commonly than red or blue receptors, resulting in deutan defects being the most common.[15,16,17,18] A clear distinction of the type of CVD could not be determined in 34.48% of cases. The Ishihara test is pretty sensitive at detection of CVD but cannot detect tritan defects and is not accurate in the differentiation of protan and deutan defects.[10] The Farnsworth Munsell D15 panel, on the other hand, can detect and classify protan, deutan and tritan defects with ease. This makes the D15 panel ideal for screening of congenital as well as acquired deficiencies of color vision.

The determination of type of CVD using D15 panel determined deutan defects to be the most common followed by protan defects. The total deutan/protan ratio (2.43) was comparable to that reported in Japanese, Europeans and Chinese.[19] Tritan defects were not observed in any individual. This was expected as tritan defects are quite rare. Congenital tritan defects are very rare in occurrence with a prevalence of less than 1 in 10000.[16]

All the cases diagnosed as CVD using the D15 panel could be classified further into protan or deutan defects including those cases which could not be classified using Ishihara test. Thus Farnsworth Munsell D15 panel was more accurate in classifying the type of CVD in individuals as compared to Ishihara test. The D15 panel is also capable of sub-classifying the type of CVD. Protan and deutan defects were sub-classified into protanomaly/protanopes and deuteranomaly/deuteranopes respectively. This classification was based on the number of crossings parallel to the deutan or protan confusion axis on the hue circle diagram. Two or more major crossing parallel to one of the confusion axis was classified as anomalies (deuteranomaly/protanomaly).[20] When the number of crossings parallel to a confusion axis were more than 6, the CVD was classified as anopia (protanopia/deuteranopia).[21] Based on these criteria, the prevalence of CVD was in the following order (deuteranomaly > protanomaly > deuteranopia > protanopia). A similar order of occurrence of CVD types has been reported in literature.[22,23]

None of the children diagnosed with CVD were aware of their color deficient status and their guardians were also ignorant about the same. Most of these students reported having faced embarrassment or difficulties in peer group when dealing with colors but were only confused regarding their situation and didn't consider the possibility of an underlying abnormality.

Conclusion:

The prevalence of congenital color vision deficiency was determined to be 4.5% using Ishihara plates and 3.72% using Farnsworth Munsell D15 panel.

The occurrence of congenital CVD was found to be significantly more common among males as compared to females.

The order of occurrence of type of defect was: deuteranomaly > protanomaly > deuteranopia > protanopia

Ishihara test and Farnsworth Munsell D15 panel were both found to be excellent handy tools in the screening of congenital CVD. Although Ishihara test had a higher sensitivity, Farnsworth D15 panel was better at classifying the type of CVD.

Farnsworth Munsell D15 panel was more likely to miss very mild cases of CVD as compared to Ishihara plates which has a practical relevance as most of these patients do not have any problem in carrying out their routine activities of life.

None of the children or their parents were aware of their color deficient status though most of them

Volume 5, Issue 1; January-February 2022; Page No 1256-1263

reported having faced difficulties or confusion with the use of colors at some point in their life.

References:

1. Davis AR, Sloper JJ, Neveu MM, Hogg CR, Morgan MJ, Holder GE. Differential changes in color and motion-onset visual evoked potentials from both eyes in early- and late-onset strabismic amblyopia. Invest Ophthalmol Vis Sci. 2008; 49: 4418–26.
2. Naresh S. Study of color blindness in Jat Sikhs. Indian J Physiol Pharmacol. 1995; 39: 127–130.
3. Paulson HM. Comparison of color vision tests used in the armed forces. In Judd DB, editor. Color vision. Washington, DC: National Academy of Science. 1973: 34-64.
4. Schwartz SH. Anomalies of color vision. In: Visual perception: a clinical orientation. 3rd edition, McGraw-Hill medical publishing Division; 2004: 147-9.
5. Birch J. Worldwide prevalence of red-green color deficiency. J Opt Soc Am A Opt Image Sci Vis. 2012; 29(3): 313-20.
6. Shah A, Hussain R, Fareed M, Afzal M. Prevalence of red- green color vision defects among Muslim males and females of Manipur, India. Iran J Public Health. 2013; 42: 16-24.
7. Gordon N. Colour blindness. Public Health. 1998; 112: 81-4.
8. Cole BL. Assessment of inherited colour vision defects in clinical practice. Clin Exp Optometry. 2007; 90: 157-175.
9. Al-aqtum MT, Al-qawasmeh MH. Prevalence of colour blindness in young Jordanians. Ophthalmologica. 2001; 215: 39-42.
10. Shrestha RK, Shrestha GS. Assessment of Color Vision Among School Children: A Comparative Study Between The Ishihara Test and The Farnsworth D-15 Test. J Nepal Med Assoc. 2015; 53: 266-269.
11. Masood T, Nazeer M, Farooq S, Saleem SM. A study of color vision deficiency in an adult Kashmiri population. Int J Curr Adv Res. 2017; 06: 4849-4853.
12. Shrestha RK, Joshi MR, Shakya S, Ghising R. Color vision defects in school going children. J Nepal Med Assoc. 2010; 50: 264-6.
13. Chandak NR, Daigavane SV, Sharma SR. Screening of colour vision deficiency in school children of Wardha District. Indian J Clin Exp Ophthalmol. 2017; 3: 80-4.
14. Pandey N, Chandrakar AK, Garg ML. Tests for color vision deficiency: Is it time to revise the standards? Indian J Ophthalmol. 2015; 63: 752-753
15. Fareed M, Anwar MA, Afzal M. Prevalence and gene frequency of color vision impairments among children of six populations from North Indian region. Genes Dis. 2015; 2: 211-218.
16. Mulusew A, Yilikal A. Prevalence of congenital color vision defects among school children in five schools of Abeshge District, Central Ethiopia. J Ophthal East Central Southern Afr. 2013; 17: 10-14.
17. Mitiku RG, Tolera BS, Tolesa ZG. Prevalence and allele frequency of Congenital Colour Vision Deficiency (CCVD) among students at Hawassa University, Ethiopia. J Egypt Public Health Assoc. 2020; 95: 10.
18. Al-Musawi BM. Prevalence of Color Vision Deficiency among Adult Males from Baghdad Province. Iraqi Academic Scientific Journal. 2014; 13: 134-9.
19. Adam A, Puenpatom M, Davivongs V, Wangspa S. (1969). Anomaloscopic Diagnoses of Red-Green Blindness Among Thais and Chinese. Human Heredity. 1969; 19: 509-513.
20. Atchison DA, Bowman KJ, Vingrys AJ. Quantitative scoring methods for D15 panel tests in the diagnosis of congenital color vision deficiencies. Optom Vis Sci. 1991; 68: 41-8.
21. National Research Council (US) Committee on Vision. Procedures for Testing Color Vision: Report of Working Group 41.

Volume 5, Issue 1; January-February 2022; Page No 1256-1263

Washington (DC): National Academies Press (US); 1981. CHAPTER 3, COLOR VISION TESTS. Available from: https://www.ncbi.nlm.nih.gov/books/NBK217823

22. Modarres M, Mirsamadi M, Peyman GA. Prevalence of congenital color deficiencies in secondary-school students in Tehran. Int Ophthalmol. 1996; 20: 221–222.
23. Abdulrahman MA. Prevalence of Color Vision Deficiency among Students in Hajand and Amad High Schools in Shekhan City. J App Res. 2017; 2: 84-88.

Table 1: Student t-test

		Gender		Total
		Male	**Female**	
CVD	**Yes**	25	4	29
	No	312	304	616
Total		337	308	645

Chi-square = 14.04, Degrees of freedom = 1, p-value = 0.0002

Table 2: Classification of type of defect assessed using Ishihara plates

Type of defect	Number	Percentage
Deutan	16	2.48% (n = 16/645)
Protan	3	0.47% (n = 3/645)
Unclassified	10	1.55% (n = 10/645)
Total	29	4.5% (n = 29/645)

Table 3: Student t-test

		Gender		Total
		Male	**Female**	
CVD	**Yes**	21	3	24
	No	316	305	621
Total		337	308	645

Chi-square = 12.42, Degrees of freedom = 1, p-value = 0.0004

Table 4: Classification of type of defect with gender specific prevalence assessed using D15 panel

Gender	Type of defect	Sub-type	Number	Percentage
Male	Deutan	Deuteranomaly	11	3.26% (n = 11/337)
		Deuteranopia	4	1.19% (n = 4/337)
	Protan	Protanomaly	5	1.48% (n = 5/337)

Volume 5, Issue 1; January-February 2022; Page No 1256-1263

Female	Deutan	Protanopia	1	0.3% (n = 1/337)
		Deuteranomaly	1	0.32% (n = 1/308)
		Deuteranopia	1	0.32% (n = 1/308)
	Protan	Protanomaly	1	0.32% (n = 1/308)
		Protanopia	0	0%
Total			24	100% (n =645)

Table 5: Student t-test

		Gender		**Total**
		Protan	**Deutan**	
Picked on Ishihara	**Yes**	3	15	18
	No	4	2	6
Total		7	17	24

Chi-square = 5.445, Degrees of freedom = 1, p-value = 0.019

Legends:

Figure 1: Color vision assessment of a student using Farnsworth Munsell D15 panel

Figure 2: Number of errors made on Ishihara chart

Figure 3: Gender wise distribution of color vision deficiencies

Figure 4: Number of major crossings on D15 panel

Volume 5, Issue 1; January-February 2022; Page No 1256-1263