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Research Article

Assessment of colour vision deficiency in medical students

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ABSTRACT

Background: Colour is often using as an important sign in medical practice. Colour vision deficiency Present in 4.5% population. Prevalence of CVD in Caucasians is 8% for male and 0.4% for female. Ishihara plates not contain design for tritan defect and mild CVD. Farnsworth-Munsell 100 Hue test detect all patterns and severity of CVD. Objectives: This study was done to find out incidence, determine patterns and severity of CVD and compare results of Ishihara plates and FM 100 hue test in medical students.
Methods: A cross sectional, comparative study was done in 500 medical students; were examined for CVD by Ishihara plates and FM100 hue test. Study data was entered and tabulated; frequency and Fischer's test used for data analysis by Graphpad Instat trial version.
Results: Ishihara plate shows 1.80% have CVD, 1.60% male and 0.20% female students; among them 7 have severe and 2 have total CVD. FM 100 Hue test shows 15% have CVD, 11.80% male and 3.20% female students; among them 66 have mild, 2 have moderate and 7 have severe CVD. The patterns of CVD 0.40% have protan, 1.40% have deutan and 13.20% nonspecific deficiency by FM 100 Hue test.
Conclusions: The prevalence of CVD is more in male students by both tests. Results of tests compared by using Fisher's exact test were statistically significant. Mild CVD and all patterns of CVD are not detected by Ishihara plates. So, we recommend FM 100 Hue test for severity and pattern of CVD.

Keywords: Colour vision deficiency, Medical students, Ishihara plates, Farnsworth-Munsell 100 Hue test

INTRODUCTION

The world which we are living blessed by nature with richness of colours, the colourful flowers, butterflies, rainbow, ocean, lush of green fields, majestic horizon sunrise and sunset derives from this gift of nature with our prime sense organ eyes. Human retina contains photoreceptors; Rods and Cones, over 100 million rods and about 60 million cones, located on outer nuclear layer of retina.[1] Rods responsible for night vision, cones responsible for colour vision. Colour vision is function of three retinal cones each with its specific sensitivity; Blue (tritan) at 414-424nm, Green (deutan) 522-539nm, Red (protan) at 549-570nm. Normal person require all these primary colours to match those within the spectrum, for normal trichromatic vision.[1]

CVD either inherited or acquired, present in 4.5% population.[1-3] The genes for red, green pigments are located on X-chromosome and blue pigment on chromosome-.[1] Congenital X-chromosome linked red green CVD is most common, associated with alteration in the gene sequences encoding the opsin X-chromosome; more common in male.[1] Prevalence of CVD in Caucasians is 8% for men and 0.4% for women.[1,4] Acquired CVD due to ocular disease, neurological disease or drug toxicity.[1]

Colour is often using as an important sign in medical practice. Many descriptive and diagnostic terms like jaundice, cyanosis, pallor, erythema, it is also using while doing ophthalmoscopy, otoscopy, histopathological and biochemistry examinations and colour coding for many new technologies.[5] So, medical students should be screened for CVD and advice about it. By screening, deficient students are aware of their limitation in observation of coloured medical signs, take care in clinical practices; which provide choice of carrier to the students.[5] Ishihara plates primarily designed for detect congenital and total CVD and widely used because of their convenience, simplicity of administration and availability. Ishihara plates are not containing designs for tritan defects, mild CVD and patients require good visual acuity to resolve the test. Arrangement tests such as FM 100 Hue test used to estimate nature and classify colour vision into normal; mild, moderate and severe hue discrimination and extent of CVD.[1] This study was done for assessment CVD and then compared the results of Ishihara's test and FM 100 hue test to identifying and quantification of colour vision abnormalities in medical students.

METHODS

Data collection

Data was collected after approval from Institutional Review Board.

Study design

A Cross sectional and comparative study.

Study area

Department of Ophthalmology, Government Medical College, Bhavnagar, Gujarat, India.

Sample size

A Total of 500 medical students were considered.

Study period

The study period was 6 months.

Risk of study

No risk involve to the Students for the study.

Benefits of the study

1. Informed choice of career can be made.
2. This study useful for detection, management and further prevention of CVD.
3. Students became aware of CVD and take care while observing important clinical sign. Ethical Consideration, Verbal explanation, informed and written consent from each participant was taken. Identity of each participant during study period, during analysis and after publication of the study will be kept confidential in future.

Inclusion criteria

1. Students who given written and informed consent.
2. Age between 18 to 26 years.

Exclusion criteria

1. Ocular abnormality-cataract, glaucoma, retinal disorders,
2. History of any intraocular surgery,
3. Visual Acuity <6/18.

Data analysis

The data was entered and tabulated in Microsoft Excel office 2007 and analyzed by using Graphpad Instat trial version, frequency and Fischer's exact test was applied. P value <0.05 considered statistically significant. *Methods* After complete ocular examination, colour vision was tested by Ishihara plates and FM 100 hue test.

Ishihara plates test

Each medical student showed 25 Ishihara plates under day light with best corrected visual acuity. The plates are held at 75cm distance from subject and tilted so that plane of paper at right angles to the line of vision with corrected visual acuity. Time consumed for each plate should not more than three seconds. Plates should be shown to each student once only. Plate 1: Introduction, Plates 2 to 9: Transformation for screening, Plates 10 to 17: Vanishing for screening, Plates 18 to 21: Intended screening, Plates 22 to 25: Protan and deutan classification.

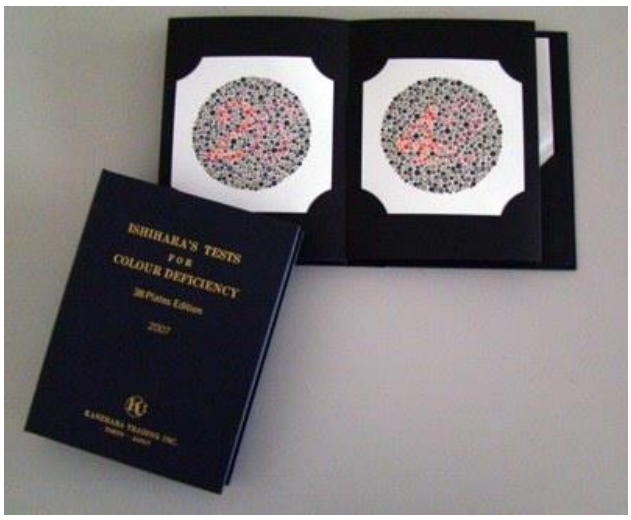

Figure 1: Ishihara plates

Analysis of the results

If first 17 or more plates are read normally, the colour vision is regarded as normal. If 14-16 plates read normal, suggest moderate CVD and requires other colour vision test and if only first 13 or less than 13 plates are read normal, the colour vision is regarded as deficient. In reference to plates 18, 19, 20, and 21, only those who read numerals 5, 2, 45, and 73 and read them easier than those on plates 14, 10, 13, and 17 are recorded as abnormal (Table 1).[6]

Farnsworth Munsell 100 hue test

Pre-test Considerations of the test as follows; (1) Test must be done in daylight under best corrected visual acuity with using binocular vision;(2) Place the computer at a working distance of 19.5 inches (50 cm) to the students. This test is online computer based test was done by http://www.color- blindness.com. During whole study same Acer laptop 15.6 inch HD LED LCD, at same plane and same brightness level was used for each students;(3) The student should be given a reasonable time to arrange the plates and may be permitted to alter the sequence prior to completion; the time should be about 2.5 minutes for each row and should not be unlimited; (4) Computer based Farnsworth 100 hue test consists of 88 different plates which are arrange in 4 distinct rows (Figure 2); (5) The aim of the test is to order the shown colour plates in the correct order and any misplacement can point to some sort of colour vision deficiency. Students will find the detailed instructions in the test itself on desktop of computer.

Table 1: Interpretation of Ishihara's plates test.

Number of Plate	Normal Person	Person with Red-Green Deficiency				Person with Total Colour Blindness
1	12	12				12
2	8	3				X
3	6	5				X
4	29	70				X
5	57	35				X
6	5	2				X
7	3	5				X
8	15	17				X
9	74	21				X
10	2	X				X
11	6	X				X
12	97	X				X
13	45	X				X
14	5	X				X
15	7	X				X
16	16	X				X
17	73	X				X
18	X	5				X
19	X	2				X
20	X	45				X
21	X	73				X
		Protan		Deutan		
		Strong	Mild	Strong	Mild	
22	26	6	(2)6	2	2(6)	X
23	42	2	(4)2	4	4(2)	X
24	35	5	(3)5	3	3(5)	X
25	96	6	(9)6	9	9(6)	X

Instructions for the test follows as; (1) Four rows of plates: At the beginning the plates of each row are mixed randomly. Only the first and the last plates of each row are set fixed and can be used as reference points; (2) Rearrange the coloured plates: In each row the plates have to be rearranged with computer's mouse by drag or drop. Then student is instructed to select the colour plate, which most closely matches the reference cap and place in the bottom of the row and slide next to the reference cap. The student then continues to select the next closest

colour disc and places each in sequence in the bottom of the row. The plates should get into a natural order so that the colours appear to change gradually in steps from left to right. When rearranging plates students have to stay within the same group which is highlighted by blue border; (3) Illegal rearrangements: Do not move any plate from one row into another one. Each row order within itself and plates cannot be mixed between rows. Do not try to move the first or the last plate of each row. These plates are not mixed randomly at the beginning; (4) Start FM 100 hue test: Click on start test.[7]

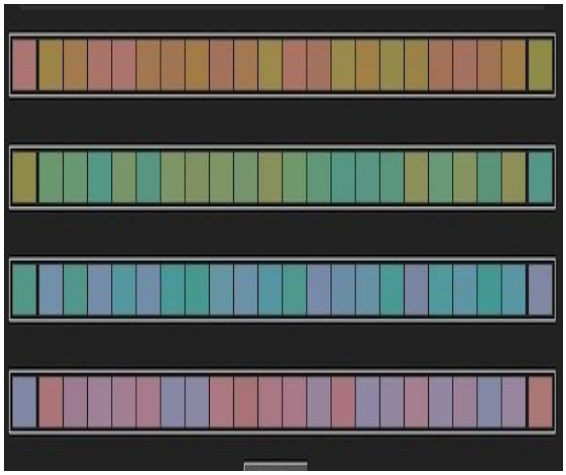

Figure 2 A: Computer based Farnsworth Munsell 100 Hue test.

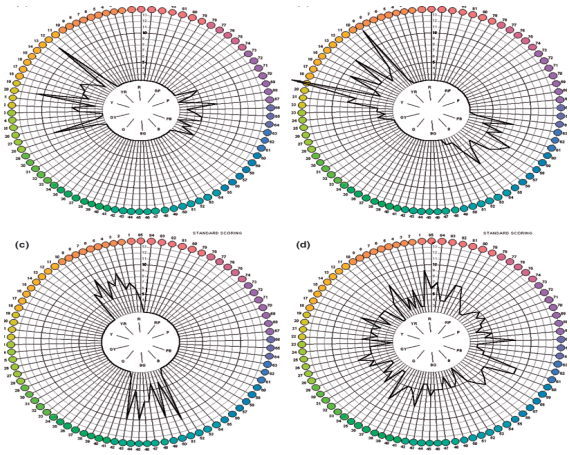

Figure 2 B: FM 100 hue test scoring sheet (a) Protan defect, (b) Deutan defect, (c) Tritan defect, (d) Non-specific defect

Total error score (TES)

If total error score <70: normal colour vision, total error score is 70 to 12: slight CVD, total error score is 120 to 200: moderate CVD, Total error score >200-:severe CVD. *Type of colour vision deficiency* if student score diagram is increased in main confusion area suggests type of colour vision deficiency- protan (a), deutan (b), tritan(c) and nonspecific deficiency (d) (Figure 3).[7]

RESULTS

This study was carried out in Ophthalmology Department, Government Medical College Bhavnagar in 500 Medical students among which 185 (37%) are males and 315 (63%) are females. Study was undertaken in age group of 18 to 26 years in Medical students, among them 328 students from age group 18-20 years, 96 students from age group 21-23 years and 76 students from age group 24-26 years.

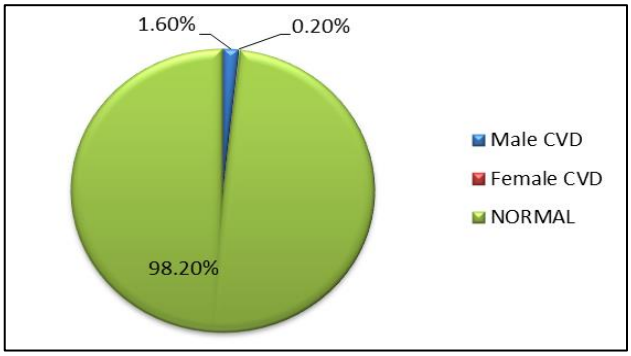

Figure 3: Ishihara plates result.

Ishihara plates results shows 491 (98.20%) Medical Students have normal colour vision and 9 (1.80%) medical students have CVD, 1.60% male and 0.20% female have CVD (Figure 3) out of 500 Medical Students. 2 Medical Student are not able to read any plates, 7 Medical Students had read <13 plates and 491 Medical Students are able to read >17 plates.

Farnsworth Munsell 100 Hue test shows 425 (85%) have normal colour vision and 75 (15%) have CVD out of 500 Medical Students. 66 students have mild CVD, 2 students have moderate CVD, 7 students have severe CVD. 0.40% have protan deficiency, 1.40% have deutan deficiency and 13.20 have nonspecific CVD and 85% have normal colour vision, 11.80% male have CVD and 3.20% female have CVD (Figure 4).

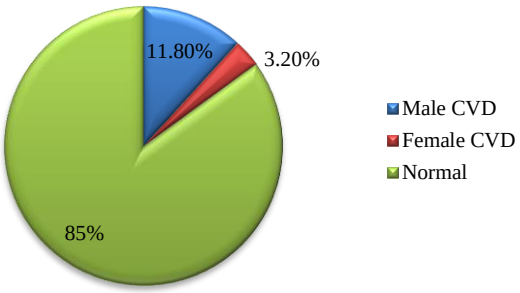

Figure 4 A: Prevalence of CVD by FM 100 hue test.

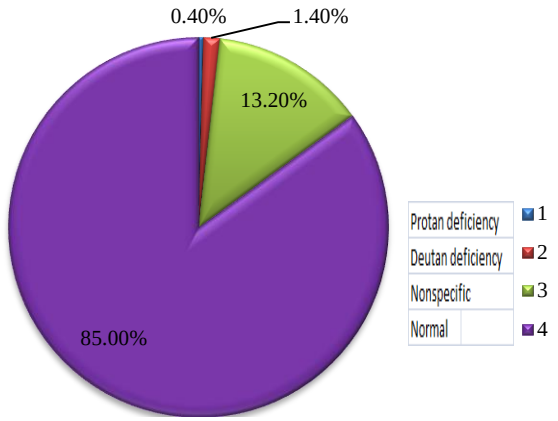

Figure 4 B: FM 100 Hue test CVD pattern.

DISCUSSION

Colour vision is essential for our daily activity like dressing, coking, driving, home decorating and sports. Most of the time CVD remains unnoticed; although it is not very rare, present in 4.5% population.[1,5] Congenital CVD has 8 % prevalence for male and 0.4% for female in Caucasians. Red-green perceptive disorders are X- linked recessive.[1,4] Medical students with CVD may have difficulty in detecting body colour changes (pallor, cyanosis, jaundice) , skin rashes and erythema , stage 1 ulcers, blood or bile in urine; sputum; vomit , colour slides, specimens, test strips, colour coded medication, charts and colour sensitive monitors, while doing ophthalmoscopy and otoscopy.[5,8] This study was done to evaluate CVD and its severity among medical students. So, students become aware about CVD and become more alert during identify coloured medical sign while examination of patient.[8,9]

Mughal IA et al reported 2000 Medical Students including 750 males and 1250 females between 18-21 age were examined for CVD using Ishihara plates, among 750 boys 18 were colour deficient (2.4%) and among 1250 girls 56 were colour deficient (4.48%).[10] Spalding JAB reported a battery of colour vision test in 38 male and 2 female, mean age 48.3 years; general practitioners 35 and specialists 5. The severity of deficiency for all doctors (n=40) was severe 22, moderate 11, and slight 7. The type of deficiency for all doctors (n=40) was deutan 33 (severe 17, moderate 10 and slight 6) and protan 7 (severe 5, moderate 1 and slight 1).[8]

Mc Culley et al compared colour vision determined by Ishihara, Farnsworth D-15 panel and HRR plates and visual acuity in 12 normal subjects. They found that colour vision testing with Ishihara test was most dependent and Farnsworth D-15 test was least dependent on good visual acuity. The differences between testing devices are multi-factorial. There are 21 characters to select from Ishihara test where arrangement tests are based on object identifying. The size of test object parallels with visual acuity, as Ishihara characters differ in width with the thinnest portions being less than 0.5cm and caps of arrangement tests having a diameter of 1cm.[11] Hardy LG et al showed that, Ishihara test is rough screening method for red green defect. It is a gross test, fails to classify type of colour vision defect and cannot be used to give satisfactory evaluation of extent and degree of defect.[12]

Study conducted by Baron et al compared CVD by HRR plates and Ishihara plates in optic neuropathy. The study group included 43 patients (48 eyes) with newly diagnosed optic neuropathy, and the control group included 33normal patients (33 right eyes). The receiver operating characteristics curve was statistically significantly better when using the HRR test (Area under curve [AUC] =0.93±0.03) than for the Ishihara test (AUC=0.77±0.05) (P=0.0006). The best specificity-sensitivity balance for the HRR was 100% and 79% respectively, and for the Ishihara test 100% and 48% respectively. They concluded that the HRR test proved to be superior to the Ishihara test in detecting acquired dyschromatopsia due to optic neuropathy.[13]

In our study 500 Medical students among them 185 are male students and 315 are female students in between 18 to 26 year age were examined for colour vision test by Ishihara plates test and FM 100 hue test. Ishihara plates test shows 1.80% have CVD (n=9) and 98.20% (n=491) normal colour vision. 1.60% male and 0.20% female students have CVD by Ishihara plates. Among them 2 students have total CVD and 7 students have severe CVD. FM 100 Hue test shows 15% have CVD (n=75) and 85% (n=425) normal colour vision. 11.80% male and 3.20% in female students have CVD by FM 100 Hue test. 66 have mild CVD, 2 have moderate CVD and 7 have severe CVD by FM 100 Hue test. 2 students have protan deficiency (0.40%), 7 students have deutan deficiency (1.40%) and 66 students have nonspecific deficiency (13.20%) by FM 100 Hue test. On comparing the results of ishihara plate's test and farnsworth munsell 100 hue test in detection of CVD are statistically significant (P<0.0001) (Table 2).The prevalence of CVD more in male as compared to female students. Ishihara plates not detect mild CVD, but with farnsworth munsell 100 hue test mild CVD was detected. The Severity and pattern of CVD is more accurately by Farnsworth Munsell 100 test.

Table 2: Comparison between Results of Ishihara plates and Farnsworth Munsell 100 Hue test.

	CVD	Normal	Total
Ishihara plate's results	09	491	500
Farnsworth munsell 100 hue test	75	425	500

Pseudoisochromatic plates-ishihara test for screening purposes, it is not provide a quantitative evaluation of colour vision or distinguish the all patterns and severity

of CVD.[12] FM 100 hue test has ability to classify all patterns and severity of CVD. FM 100 hue test is a time consuming and relative more cooperation needed as compare to other test and complicated for both patient and ophthalmologist. By this test mild CVD is detected but specific pattern of CVD not detected due to less colour confusion lies in specific axis. Same brightness, plane and colour contrast required on computer based test. Screening tests such as ishihara plates are quick and simple to use but colour discrimination cannot be quantitatively evaluated. Other arrangement tests such as farnsworth D15 test are not exact enough because of large chromaticity steps. So, we recommend Ishihara plates for rough screening CVD and FM 100 hue test for determination of severity and pattern of CVD.

CONCLUSION

The prevalence of CVD is more in male students by Ishihara plates and FM 100 Hue test. Ishihara plates shows 1.80% CVD in which 1.60% male and 0.20% female students. FM 100 Hue test shows 15 % CVD in which 11.80% male and 3.2% female students. Ishihara test detect total CVD in 2 and severe CVD in 7 students. FM 100 Hue test showing mild CVD in 66, moderate CVD in 2, severe CVD in 7 students and 0.40% have protan deficiency, 1.40% has deutan deficiency and 13.20% students have nonspecific deficiency.

The results of CVD by ishihara plates and FM 100 Hue test compare by using Fisher's exact test is statistically significant ($p<0.0001$). The FM 100 Hue test detects mild CVD in 66 medical students. Ishihara plates not detect mild CVD and all patterns of CVD. The severity and all pattern of CVD are well detected by FM 100 Hue test. We recommend FM 100 Hue test for severity and patterns of colour vision deficiency.

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