Original Article

Color Vision Deficiency in Pakistan Railways Employees

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Purpose: To determine the frequency of color vision deficiency (CVD) in Pakistan Railways employees

Study Design: Cross sectional descriptive study.

Place and Duration of Study: Outdoor patient department of Ophthalmology, Pakistan Railways Hospital, Rawalpindi over a period of one year from 1 Feb 2015 to 30 Jan 2016.

Material and Methods: Prospective Data was collected by using convenient non probability sampling technique of Pakistan railways employees presenting for the annual vision checkup. Slit lamp was used to evaluate the anterior and posterior segments whereas visual acuity was measured on the Snellen's chart after refraction. Color vision was assessed binocularly using the Ishihara isochromatic color plates (38 plates) with the best correction in a trial frame. The type of color vision deficiency was labeled from the Ishihara chart key. The patients with best corrected visual acuity 6/9 after refraction and no history of medication or surgery were included in the study. The patients who had visual acuity <6/9, medication history of anti tuberculosis, central nervous system acting drugs or ocular surgical history were excluded from the study.

Results: A total of 1000 candidates full filling the inclusion criteria were included in the study. Patient's age ranged from 20 years to 52 years with mean age of 32.21 ± 8 years. CVD was found in 5.1% of patients and all of them were males.

Conclusion: The screened population was unaware of their CVD and had never undergone any color vision screening test indicating that the knowledge and the information on CVD is lacking in Pakistan.

Key words: color vision, Ishihara chart, Screening, Visual Acuity.

The Human eye is unique in having trichromatic vision and a visual sense to differentiate between dissimilar wavelengths of light[1]. This is possible because of the presence of three unique types of retinal photoreceptors called the cones (red, green and blue) having specific pigments[1]. The cones detect an appropriate mixture of red, green and blue lights which enables the eye to match any color which is visible to it. When this normal trichromatic vision is absent in a person he or she is labeled as having abnormal color vision, color vision deficiency[2], or commonly the flawed name, color blind.

In CVD a person is unable to differentiate among certain colors due to the absence, malfunction, or alteration of one (dichromatism), two (monochromatism) or all (achromatism) of the photo pigments[3]. In Dichromats color vision is only because of two pigments. The Dichromats in which there is absence of green cones are called deuteranopia, while those with of red cones deficiency are called protanopia and those with absence of blue cones are called tritanopia. Mild forms of defective color vision are called Anomalous trichromacy and the terms protanomaly, deuteranomaly and tritanomaly are given in red, green and blue pigments defects,

respectively. Color vision deficiency can be acquired due to optic nerve disease or medication but is usually congenital[4]. Clinically the congenital CVD is characterized as partial (red-green and blue-yellow) and total color vision deficiency[5].

Throughout the world CVD is taken as an occupational hazard with severe troubles happening in everyday life. Mostly patients with CVD are never aware of their deficiency which results in various handicaps[1]. The problems they face include career selection (33%), disability in job (25%), traffic signal recognition (13%) and judgment in daily routines (75%)[6]. Even in medical profession, color is a clinical sign for identifying anemia and cyanosis, which is vital in recognizing and diagnosing diseases[7].

In the literature CVD has been reported from many countries and populations. The prevalence of color vision deficiency in Europe is reported to be 6.0% in males and 0.25% in females.[5] Another study done in Australia showed prevalence of CVD 7.4% in males and 0.7% in females[7] whereas in Asian population it is reported as 4.9% in males compared to 0.64% in females[6]. In Pakistan very little data is available regarding CVD and population based studies are lacking. The aim of our study was to provide information to fill the gap.

MATERIAL AND METHODS

It was a cross sectional descriptive study, with non probability convenient sampling, done at outdoor department of ophthalmology, Pakistan Railways Hospital. The principles outlined in the Declaration of Helsinki (2008) were followed for the conduction of study and a formal approval from the ethical review committee was obtained for the conduction the study. With informed consent, Data was collected of all Pakistan railways employees presenting for the annual vision checkup during a period of year from Feb 2015 to Jan 2016. A sample of 1000 was estimated using the standard formula:

$$\mathbf{n = \frac{Z2P\,(1 - P)}{d2}}$$

Where:

n = sample size

Z = Z statistic for a level of confidence (95% level of confidence used, therefore Z value is 1.96)

P = expected prevalence of proportion (0.0554),

d = precision (0.02)

Detailed history using a structured questionnaire including age, gender, occupation, any medication or surgery was recorded by the authors and later examination was done. Visual acuity was measured on the Snellen's chart (after refraction if required). The patients with best corrected visual acuity 6/9 after refraction and no history of medication or surgery were included in the study. The patients who had visual acuity < 6/9, medication history of Anti Tuberculosis, Central Nervous System acting drugs or ocular surgical history were excluded from the study. Anterior and posterior segment examination was done by using slit lamp biomicroscopy and a condensing lens. Color vision was assessed binocular with the best correction in a trial frame using the Ishihara isochromatic color plates (38 plates). The color vision plates were held about 75 cm from the patient parallel to the face of the patient and perpendicular to the line of sight of the patient. The Ishihara chart is a group of polychromatic plates in which figures are printed by colored spots with a background of likewise shaped colored spots. The figures are prepared in such a manner that to a patient of CVD they will give the impression of being the same as the background. Each plate was shown to the patient for 3 to 5 seconds and they were asked to read the numbers in the color chart. The numbers read by a normal color vision patient were different from the patients with color vision deficiency. The documentation of the result was done as type of color vision deficiency with the help of the chart key. Data was entered and analyzed using the SPSS version 22. The age was analyzed by descriptive method with range and mean ± SD where as the qualitative variables were analyzed as frequencies and percentages.

RESULTS

During the study period a total of 1178 patients presented to the hospital for annual checkup among which 1000 candidates full filling the inclusion criteria were included in the study. Majority of the patients were males 95.8%. Patient's age ranged from 20 years to 52 years with mean age of 32.21 ± 8 years. CVD was found in 5.1% of the patients, all males (Table 1). Among the CVD patients 3.4% had red green color defect, 0.4 % had green color defect and 1.3% were total color blind. The screened out patients were unaware of their CVD and did not report any difficulty in their job.

Table 1: Color vision deficiency among the different employees.

Occupation	Red green color defect n (%)	Green color defect n (%)	Total color blind n (%)	Total (n=1000) n (%)
Constable	18 (1.8)	3 (0.3)	5 (0.5)	26 (2.6)
Sub inspector		1 (0.1)	3 (0.3)	4 (0.4)
Cabin man	4 (0.4)			4 (0.4)
Assistant driver	2 (0.2)			2 (0.2)
Guard	5 (0.5)			5 (0.5)
Head clerk	3 (0.3)			3 (0.3)
Point man/ signal clearer			3 (0.3)	3 (0.3)
Gate man			2 (0.2)	2 (0.2)
Assistant	2 (0.2)			2 (0.2)
	34 (3.4)	4 (0.4)	13 (1.3)	51 (5.1)

DISCUSSION

Color vision deficiency or color blindness is not blindness at all. It is the reduced ability of the eyes to see colors. CVD is a not a fatal disorder; therefore most of the patients with CVD remain ignorant of the deficiency since their vision remains normal otherwise [10]. A patient with CVD may misidentify, confuse, and fail to notice or notice color less quickly than normal. This is because of underdevelopment or absence of one or more retinal cones which are responsible for detecting colors in light and transmitting them to the optic nerve and later to the brain. CVD is classified by type (protan, deutan or tritan) as well as the extent which can be mild, moderate or strong. Protans have a red-green color vision deficiency caused by an anomaly in the red-sensitive retinal cone cells. Protans typically confuse between orange versus green, red versus black, blue versus purple and light red (or "salmon") versus gray. Deutans have a red-green color vision deficiency caused by an anomaly in the green-sensitive retinal cone cells. Deutans typically confuse shades of yellow versus green, green versus gray and magenta (or "pink") versus gray. Tritans have a blue-yellow color vision deficiency caused by an anomaly of the blue-sensitive retinal cone cells. Tritans typically confuse shades of yellow versus gray and blue versus gray. It is usually a hereditary genetic disease which is present since birth but the person remains unaware of it until screened for it. The genes producing photo pigments are passed on via the X chromosome and hence there is a higher possibility of CVD in males, if any genes are damaged.

Some researchers claim that the ability to discriminate color changes throughout a person's life. Kim S[11] found an improvement in color discrimination while checking color vision from childhood to adolescence. But others believe this improvement might be because of the person's ability in understanding the tests over the passing years. According to Tiffin and Ikoro NC[12] discrimination remains stable until approximately 40 years and then begins to decline due to pupil miosis, which decreases retinal illumination, yellowing of the human lens, and an increase in retinal diseases occurring in later life.

Nagel anomaloscope is the standard test to measure adult red/green color vision[13]. In the test the subject simultaneously adjusts red and green mixture against the yellow field to achieve a precise color and brightness matching. It is very accurate in determining color anomaly but is a meticulous and difficult process[14]. In addition; the equipment is rather burdensome and expensive. More manageable and cheaper alternatives are Farnsworth 100 hue test and its reduced version, the D15 panel. However, these test demand a good cognition while arranging color chips in a predefined spectral order and is easier said than done. In screening for CVD, the purpose is only to detect if it is present or not. Protan and Deutan defects are the highest in congenital CVD. For this the Ishihara

test is reliable, having a mean sensitivity of 96% and the mean specificity of 98.5%[6], therefore serve the purpose of screening.

Large random population surveys have reported CVD in 0.4% women[10]. In our study none of the females had CVD. This is contrary to the previous studies in which the reported CVD in women in Denmark is 0.54%, in Greenland is 0.4%, Ethiopia 0.2%, Iraq 3.2%, Iran 0.43%, Jordan 0.33%, Spain 0.75% and Saudi Arabia 0.75%[15]. On the other hand we detected CVD in 5.1% males in our study whereas reported CVD worldwide in males are: India 8.73%[7], Belgium 8%, United States 8%, Turkey 7.33% and China 6.5%[16]. Universally CVD is detected more in males as compared to females[17]. The abnormality is inherited as X linked recessive disease[18] therefore males are affected and females act as carriers. The female carriers of the abnormal gene have 50% chance of abnormal color vision for sons whereas the CVD males pass on their X-chromosomes to daughters only, which leads to all daughters as carriers and sons with normal color vision.

A person with CVD is considered to be handicapped in comparative color tasks. In everyday life CVD imposes significant hazards like recognizing traffic signals and signs while driving a car, judging the freshness of fruits, choosing and preparing food, gardening, and even selecting clothing. Therefore in many occupations CVD is considered a handicap e.g. telecommunication, electrical mechanics, seamen, train drivers, air traffic controllers, painters etc. CVD can lead to difficulty in detecting color codes on electrical components, end points in chemical tests, problems in industries like paint, textile and plastics; leading to inappropriate and unsafe function[19]. In Railways organization, people concerned for the control of train movements must be able to distinguish red, yellow and green signals at one kilometer distances[20]. We in our study found 2 assistant drivers and 3 signal clearers suffering from CVD. When inquired, they reported no difficulty in performing their tasks. One probable reason for this could be that they have trained themselves over the years as how to differentiate between different colors by the help of other clues like numbers, shape, size and pattern. This finding is a concern and emphasizes mandatory CVD screening in all professions as most of people are unacquainted of their CVD and do not report any difficulty in their job. Even in medical profession people are unaware of their CVD because screening policy does not exist in most countries[21].

Although CVD does not cause any significant disability but till now no treatment or surgical procedure has been proven to recover the chromatic vision [10]. In the past techniques like warming one's eye, stimulating by electricity, injecting iodine or cobra venom extracts[22] and multivitamins were advocated but it was concluded that no method can correct CVD. Special contact lenses and glasses[23] have been designed that may help people with CVD to tell the difference between similar colors but clinical trials are awaited. Further ongoing research for CVD involves gene technology using an injection of an adenovirus to get the genes into the cone cells of the retina of squirrel monkeys[24]. Researchers have shown promising results but human trials are awaited.

We know the limitations of our study. The study is based on data of a particular hospital and it is not population based; hence does not give a true measure of the incidence and prevalence of CVD in the population of Pakistan but it might prove helpful for further population based studies.

CONCLUSION

In our study found we CVD was present in 5.1% of the candidates. The screened population was unaware of their CVD and had never undergone any screening test indicating that the knowledge and the information on CVD is lacking in Pakistan.

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