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Research Article

A STUDY OF COLOR VISION DEFICIENCY IN AN ADULT KASHMIRI POPULATION

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A B S T R A C T

Background: Many people in the world are color blind as they are affected by the color vision deficiency. Most of them remain undetected for their whole life because of unawareness about the disease or they simply adapt to the external environment. Looking at the morbidity associated with color vision deficiency, we aimed at conducting this study in Kashmir division to estimate the burden of color vision deficiency in adult Kashmiri population. **Material and Methods:** This cross-sectional study was conducted by Postgraduate Department of Physiology, Government Medical College, Srinagar from April 2015 to October 2016 in Kashmir division of J&K State. Sampling was done using Multi stage sampling method. Detailed informed consent was taken from patients and relevant information regarding name, age, gender, consanguinity, marital status, education, medical history and drug history were collected on structured Proforma. Color vision testing was done using Ishihara pseudo isochromatic plates (38 plates -latest edition). Ishihara 38 plates edition contains 38 plates in which 25 plates are for literate subjects while 13 plates are for illiterate subjects. **Results:** A total of 3110 participants were included in the study. The mean age of the study participants was 34.72 +_14.862 years. Only 246 (7.9%) of the study participants were having history of Consanguineous marriage. Most of the participants 2544(81.8&) were educated and 2012 (64.7%) were married. The estimated prevalence is 4.7%.Among the types of color vision deficiency, Deuteranomalia is the most common type prevalent in the Kashmiri population. **Conclusion:** The assessment of color vision deficiency by Ishihara pseudo isochromatic plates is rapid, cost efficient and sensitive in detecting red-green color vision deficiency. Researches may attempt to formulate hypothesis regarding causal relationship, frequency and significance of color vision deficiency in human population

INTRODUCTION

The group of conditions affecting the perception of color is referred as Color vision deficiencies. Color and electromagnetic radiations of certain range are specifically associated to each other and are visible to the human eye. The three cone cells of the retina i.e: Red, green and blue perceive the color and generate signals to the brain. In the brain, these signals mix with each other to create wide spectrum of colors that humans perceive. The peaks of their absorbance curves fall at ~420, 530, and 560 nm, which correspond to the violet, yellow-green, and yellow-red regions of the spectrum. Because the nervous system can compare the *relative* stimulation of the three cone types to decode the wavelength, it can also distinguish changes in the intensity (luminance) of the light from changes in its wavelength (1). Clinically color vision deficiency is classified in to 1) protan 2) deutan and 3) tritan types. Protan and Deutan defects are caused by recessive mutations of the genes located on the long arm of the X-chromosome within Xq28 band. Tritan defects are caused by mutations of the gene encoding blue retinal cone pigment present on the autosomal number 7. Tritan defect is autosomal dominant and transmitted with incomplete penetrance. Color vision deficiency can be congenital or acquired. Congenital color deficiencies (CCVD) are genetic disorders inherited from parents and can be red-green which is sex-linked or blue-yellow which is autosomal dominant. Congenital red-green form is x-linked recessive while as acquired color vision deficiencies (ACVD) can occur due to many reasons (2). The incidence of color vision deficiencies varies from race to race and different in different geographical

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regions of the world inhabited by different ethnicity (3). In developed world, about 8% of men and 0.4% of women have color vision deficiencies. Females have low incidence as low as 0.6-1% (4). Lowest incidence rate of 2% have been observed in North America, South America, Fiji and in certain Asian Indian tribes (5).

Many people in the world are color blind as they are affected by the color vision deficiency. Most of them remain undetected for their whole life because of unawareness about the disease or they simply adapt to the external environment. Certain professionals like traffic policemen, pilots, sea divers, road transport vehicles, railway engine drivers, bus and truck drivers, workers in textile industry where dyeing of cloth requires a high degree of color perception, paint and printing industries, interior decorators and visual artists require normal color vision to perform their duties efficiently. Color vision deficiency in such professionals is a matter of concern and a big public health problem. Even children in school who suffer from color vision deficiency having difficulties in certain aspects while learning in school (6). Looking at the morbidity associated with color vision deficiency, we aimed at conducting this study in Kashmir division to estimate the burden of color vision deficiency in adult Kashmiri population. The results of this study are helpful for government organizations and policy makers to formulate and include recommendation in National Programmes.

MATERIAL AND METHODS

This Cross-Sectional Study was conducted by Postgraduate Department of Physiology, Government Medical College, Srinagar from April 2015 to October 2016 in Kashmir division of J&K State. Ethical clearance from the institutional ethical committee was taken before the start of study. Sample size was derived using the formula for estimating prevalence. Absolute precision of 2%, design effect of 1 and past prevalence of C.V.D as 2%, sample size came out to be 3110. Sampling was done using Multi stage sampling method. Kashmir division has 10 districts as per census 2011. All the districts were line listed and three districts were randomly selected by lottery method namely District Baramulla, District Srinagar and District Budgam. Within each district, medical blocks were line listed and one medical block was selected by simple random sampling using lottery method. I.e. block Sopore (district Baramulla), block Chadoora (district Budgam) and SMHS hospital (district Srinagar). Then in each selected medical block all the district and sub-district hospitals (SDH) were line listed and one hospital was selected randomly using lottery method. SDH Sopore (block Sopore), SDH Chadoora (block Chadoora) and SMHS hospital (block Srinagar).Then from each hospital patients attending the outpatient department aged 18-60 years were consecutively selected to achieve the required sample size. Patients with diagnosed ocular diseases like Glaucoma, Macular diseases, Retinitis pigmentosa, Strokes affecting eye, Alzheimer's disease, Parkinson's disease, Leukemia, Diabetes mellitus, Liver diseases, Chronic alcoholism, Multiple sclerosis, Sickle cell anemia and Hypertension were excluded. Patients on drugs like antibiotics, barbiturates, anti tubercular drugs, anti-hypertensive drugs to treat nervous disorders were also excluded.

Detailed informed consent was taken from patients and relevant information regarding name, age, gender, consanguinity, marital status, education, medical history and drug history were collected on structured Proforma. Color vision testing was done using Ishihara pseudo isochromatic plates (38 plates -latest edition). Ishihara 38 plates edition contains 38 plates in which 25 plates are for literate subjects while 13 plates are for illiterate subjects. Figures are written on 25 plates for literates while as wavy lines are drawn on 13 plates for illiterates.

Subjects were made to sit in adequately lighted room resembling natural day light (care was taken to avoid direct sun light or use of electric light to avoid interference in reading color plates).Visual acuity was checked. Subjects using spectacle were asked to read with spectacles. The color vision testing plates were held at 75cms from the subject and tilted at right angle to the line of vision. The subjects were shown first plate to demonstrate then pages were turned one by one. The subjects were asked to read numbers seen on the plates. The illiterate subjects and literate subjects were given 10 and 3-5 seconds each for reading, respectively. Illiterate patients / subjects were made to trace lines with finger between x-axis. Scoring was done and diagnosis of red-green color vision deficiency of congenital type was made.

Statistical Analysis: Data was entered in Microsoft Excel spread sheet 2007 and analyzed using SPSS v.20.0 software. Descriptive variable were expressed by mean and Standard Deviation. Categorical variables were analyzed using Chi-square test. p value < 0.05 was considered statistically significant.

RESULTS

A total of 3110 participants were included in the study.1462 (47%) were males. The mean age of the study participants was 34.72 +_14.862 years.871 (28%) and 892 (28.7%) belong to the age group of 21-30 & 31-40 years respectively. Only 246 (7.9%) of the study participants were having history of Consanguineous marriage. Most of the participants 2544(81.8&) were educated and 2012 (64.7%) were married. [Table I]

Table I Demographic Characteristics of the Study Participants

Variable	Frequency (n=3110)	Percentage
Sex		
Male	1462	47.0
Female	1648	53.0
Age range in years		
<= 20	423	13.6
21 - 30	871	28.0
31 - 40	892	28.7
41 - 50	583	18.7
51 - 60	341	11.0
Marriage		
Consanguineous	246	7.9
Non-Consanguineous	2864	92.1
Educational Status		
Literate	2544	81.8
Illiterate	566	18.2
Marital Status		
Married	2012	64.7
Unmarried	1098	35.3

Table II shows prevalence of color vision deficiency disorder in Kashmir division. The estimated prevalence is 4.7% [CI: 4.57-4.83]. Among the types of color vision deficiency, Deuteranomalia is the most common type prevalent in the

Kashmiri population i.e: 52.74% followed by Protanopia (21%).

Table II Prevalence of C.V.D & Type of C.V.D in Study Participants

Variable	Frequency	Percent
Prevalence of C.V.D.		
Present	146	4.7
Absent	2964	95.3
Total	3110	100.0
Type of C.V.D.		
Deuteranomalia	77	52.74
Protanopia	31	21.23
Deutranopia	21	14.38
Protanomalia	17	11.64
Total	146	100.0

C.V.D: Color Vision Deficiency

The prevalence of color vision deficiency was highest among males (8.5%) than females (1.3%) and the relation was statistically significant with p< 0.001. Deuteranomalia was seen more among males (55%) than females (41%). One important finding to mention here is the higher prevalence of Protanopia & Protanomalia in females than men [Table III]. Out of 3110 subjects tested, 1585 subjects were having errors on Ishihara color vision testing plates. Of the 1585 subjects with errors on testing, 976 (61.5%) had 1-2 errors only [Figure I].

Table III Distribution & Type of C.V.D in Study Participants as per gender

Variable	Frequency	Percentage	p Value	
Sex				
Male	124	8.5	Chi-square=87.32	
Female	22	1.3	p-value<0.001	
Total	146	9.8		
Type of C.V.D	Frequency In Males	Percentage	Frequency In Females	Percentage
Deuteranomalia	68	54.8	9	40.9
Protanopia	26	21.0	7	31.8
Protanomalia	16	12.9	5	22.7
Deuteranopia	14	11.3	1	4.5
Total	124	100	22	100

C.V.D: Color Vision Deficiency

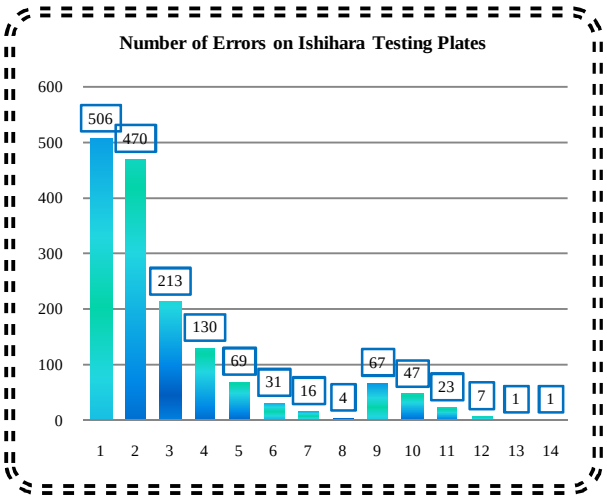

Figure I Bar chart showing number of errors on Ishihara color vision testing plates in the study subjects

DISCUSSION

Color vision is one of the most intriguing phenomenons of the visual experience and has been the subject of study from vision scientists to philosophers of perception (7). The world of color presents no more surprising phenomenon than that of color blindness which is ever playing a mysterious back stage role in human experiences (8). Color blindness is non-fatal disorder; therefore color blind people usually remain unaware of the defect since their vision is otherwise normal (9).Congenital color vision deficiency is one of the commonest inherited disorder of vision. Certain rare forms of congenital color vision deficiency result in profound visual impairment (10).

The present study provides a detailed description of red-green color vision deficiency for the first time among adult Kashmiri population and thus provides the basic epidemiology tool for color vision deficiency in the region. In our study, we took 3110 subjects with 1648 (53%) female subjects with 1462 (47%) male subjects. Al-Aqtum MT *et al* (2001) (11) in their study took 1418 subjects with 1200 (85%) females and 218 (15%) males. Sutender Naresh (1995) (12) also included 2097 subjects with 1306 (62.27%) males and 791 (37.73%) females. We observed an overall prevalence of 4.7% [CI: 4.57-4.83] in our study which is consistent with the study done by Zein ZA (1990) (13) who observed an overall prevalence of 4.2% in Ethiopian population. Chan YK *et al* (1992) (14) also found 4.8% overall prevalence in Singapore. The prevalence of color vision deficiency among males was 8.5% and in females it was 1.3%. Our results go with the prevalence of color vision deficiency in European Caucasians who reported 8% in men and 0.4% in women (Birch J, 2012) (15), Al-Aqtum MT *et al* (2001) (16) observed 8.72% prevalence of CVD in males and 0.33% prevalence in females in Jordanian population. Modarres M *et al* (1996) (17) also reported a prevalence of 8.18% in males in their study in Iranian population while as Cabrera FJ *et al* (1997) (18) in Spain and Irfan Mughal *et al* (2013) in Pakistan reported a prevalence 4.69% and 2.4% respectively in men which is lower than our study.

Males tend to have higher color vision deficiency frequency than females which reinforces the fact of x-linked recessive nature of the defect (i.e. one single x-chromosome in males is predominant to CVD while females with two x-chromosomes can act as dosage compensation and decreases the risk of the disease. We had a study population ranging from 18 years to 60 years with maximum subjects 1763 (56.7%) aging 21-40 years. Sutender Naresh (1995) (19) studied subjects aged 10-60 years, and Navjot Kaur (2011) (20) conducted a study on subjects ageing 11-60 years which is in accordance with the findings in our study. A total of 2864 (92.1%) marriages in our study were non-consanguineous while as 246 (7.9%) were consanguineous. Since it is a genetic disorder and x-linked recessive therefore plays a role in CVD. We could not find any study which mentioned consanguinity therefore could not compare our results.

Out of a total of 3110 subjects, 2544 (81.8%) were literate and only 566 (18.2%) were illiterate. Since literacy rate of Kashmir according to Census 2011 is 65.5% hence both literates and illiterates formed our study population. Also Ishihara test type has plates for both literates and as well as illiterate subjects separately. No other study in literature has included literacy as their parameters therefore we could not compare the results.

In our study, we had 146 (4.7%) color vision defective subjects in which 77 (52.74%) had Deuteranomalia, 31

(21.23%) had Protanopia, 21 (14.38%) had Deuteranopia and 17 (11.64%) had Protanomalia, so the commonest type of CVD in our study is Deuteranomalia (Deuteranomaly) which is consistent with the study done by A. Singh *et al* (2009) (21), Sutender Naresh *et al* (1995) (22), Huang SI *et al* (1990) (23). Matthew Oriowo *et al* (2008) (24) in their study also found Deutran defects more common than protan defects). In a study done by Mohd. Fareed *et al* (2015) (25) in their study found Deuteranomalia as the commonest type of CVD in their subjects.

It is suggested that Caucasians have comparatively fewer green pigment genes than that of the Asians and the American Blacks (Cruze EM *et al*., 2010) (26). It is also suggested by several researchers that green color receptors are commonly affected more than red or blue receptors. (Ahsana Shah *et al*, 2013) (27).In our study, out of a total of 3110 there were 1462 males and 124 out of these were having color vision deficiency in which 68 (54.8%) had Deuteranomalia followed by 26 (21%) who had Protanopia, 16 (12.9%) had Protanomalia and 14 (11.3%) subjects had Deuteranopia as the type of color vision deficiency, while as out of 1648 females, 22 (100%) have color vision deficiency which includes Deuteranomalia i.e. 9 (40.9%) followed by Deuteranopia 7 (31.8%), Protanopia 5 (22.7%) and Protanomalia 1 (4.5%). Our study is consistent with the findings of Saumya Agarwal *et al* (2014) (28) in which he observed that out of 11 boys with color blindness, 10 boys (2.87%) showed deuteranomalia and 1 (0.29%) showed Protanomalia where as the only girl showed deuteranomaly. Color vision deficient subjects remain undetected because of their unawareness about the defect. Although color vision deficiency is non-fatal, it offers distinct disadvantage to those affected by the disorder, besides that people with color vision deficiency are barred from certain professions. Since congenital color vision deficiency is a lifelong condition and there is no permanent treatment, various adaptive strategies may be helpful. Ishihara pseudoisochromatic test plates are cost effective, simple, non-invasive, quick and easy to carry for diagnosing and screening congenital color vision deficiency. These plates provide efficient sensitivity and specificity in detecting red-green color vision deficiency. Color vision deficiency is currently under-diagnosed as the screening for color vision deficiency is not well appreciated and even Ophthalmologists neglect this aspect of vision.

Recommendations

Increasing the awareness about color vision deficiency and its impact on various stages of life. Genetic counseling in the regions with high prevalence of color vision deficiency will decrease the birth of children with this deficiency. Population based screening for color vision deficiency is one of the most important steps to initiate appropriate measures and plan adaptive strategies. Teachers should be trained to perform screening test for color vision deficiency along with visual acuity in schools and to modify their means of teaching in order to accommodate children with the deficiency. Screening in college especially medical colleges at the time of admission can be valuable in determining career options as well as specializations. Doctors with color vision deficiency should avoid following specialties where normal color vision is crucial i.e. Histopathology, Microbiology, Hematology, Dermatology, Ophthalmology, Surgery and Anesthesia. Test for color vision should be a part of ophthalmic examination.

CONCLUSION

Our study of color vision deficiency among adult Kashmiri population shows the significant gender based difference in the frequency of color vision deficiency, with higher in males (8.5%) than in females (1.3%). The assessment of color vision deficiency by Ishihara pseudo isochromatic plates is rapid, cost efficient and sensitive in detecting red-green color vision deficiency. Researches may attempt to formulate hypothesis regarding causal relationship, frequency and significance of color vision deficiency in human population. People with color vision deficiency face wide range of difficulties in day to day life but due to unawareness about their problem they either neglect or adapt to it. Early detection of the problem by active screening and by increasing awareness help the color vision deficient people to make adaptive and behavioral strategies to deal with potential difficulties they face during various stages of life.

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