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Screening of colour vision deficiency in school children of Wardha District

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Abstract

Introduction: Colour vision in humans is trichromatic. Colour vision deficiency (CVD) occurs when one or more of cone types are absent, or present but defective. It is a common X-linked genetic disorder. However, most colour blind children remain undetected due to absence of proper screening. Therefore, this cross-sectional study was carried out to determine the prevalence of CVD, type of CVD and prevalence of each type among school children of Wardha District.

Materials and Methods: 850 school children in the age of 10-15 years were screened for CVD using Ishihara's pseudoisochromatic test 38 plate edition.

Results: Of 850 school children, 18 children (2.1%) (95% confidence interval: 1.35-3.33) suffered from CVD. Prevalence rate for CVD was found to be higher in males (3.7%) than in females (0.4%). The overall trend of defects was: deuteranomaly > deuteranopia > protanomaly > protanopia. The prevalence of congenital dyschromatopsia in school children of Wardha District was comparable to prevalence rates across India.

Conclusion: Early diagnosis of congenital dyschromatopsia would allow for minimization of these problems, improvement of adaptation of children to their dysfunction, and, most importantly, for better planning of their professional future.

Keywords: Colour vision deficiency, Dyschromatopsia, Ishihara, School children

Introduction

Human beings have the special ability to see in colour, which distinguishes them from other species.(1) Colour vision is the ability to discriminate a light stimulus as a function of its wavelength.(2)

The Young Helmholtz theory of trichromatic colour vision, postulates the existence of three kinds of cones, each containing a different photo pigment which is maximally sensitive to one of the three primary colours. Normal, or trichromatic, colour vision is mediated by three types of cone photoreceptors – designated short- (S), middle- (M), and long- (L) wavelength-sensitive, showing peak absorbencies at light wavelengths of 415 nm, 530 nm and 560 nm, respectively. Blue, green and red are thus called primary colours as any colour can be produced by mixing appropriate proportion of these three colours.(3)

Colour vision deficiency (CVD) or dyschromatopsia is the inability to distinguish certain colours.(4) Molecular studies have shown that defects in colour vision result from the absence, malfunction, or alteration of one (dichromatism), two (monochromatism) or all (achromatism) of the photopigments. Dichromats base their colour vision on only two pigments. The class of dichromats characterized by the entire absence of blue, green and red are called tritanopia, deuteranopia and protanopia respectively while those characterized by a relatively mild form of defective colour vision for blue, green and red are called as tritanomaly, deuteranomaly and protanomaly respectively.(5,6)

Impairment in colour vision can be either hereditary or acquired. Many people are affected by colour blindness but many of them remain undetected as they simply adapt to the environment to certain extent and also because of unawareness of the disease.

The current rationale for school screening for CVD is the potential preclusion from occupations such as driving, flying, defence services, engineering and medicine. Cole stressed that school children should know if they have CVD so they can be helped more quickly to find adaptive strategies and be able to take it into account when planning their career.(7)

Literature search revealed no report about the prevalence rates of CVD among school children in Wardha District. Therefore, this study aimed to assess the prevalence of CVD among school children in Wardha District, to compare the prevalence rate among male and female children and to find out the type of CVD in affected individuals and prevalence of that particular type.

Materials and Methods

A descriptive cross-sectional study was conducted in March, 2015 in Wardha District of Central India.

A multistage sampling method was employed. The first 8 primary schools in the district were selected randomly by using table of random numbers among 25 primary schools in the district. Next, from each selected school, school children in the age of 10-15 years who were able to read numbers were selected. Children who were healthy with no abnormal ocular findings, were included in the study. Participants on chronic drug therapy for more than one month or with systemic illness or who had history of ocular or head injury which significantly affected vision were excluded from the study. However, we didn't encounter participants with

these exclusion criteria during the survey and children from the selected 8 schools were screened for CVD.

Using the WHO Manual for sample size determination in health studies, with an anticipated population proportion of 8%, absolute precision of 2% at 95% confidence interval, design effect of 2 and with the assumption of 90% response rate, the minimal sample size required for this study was calculated to be 846.[8] Following a simple random sample and a sampling fraction of 50%, a total of 850 children were interviewed and tested for CVD.

The study tools consisted of Snellen's chart, Ishihara chart and a structured questionnaire, which included demographic data like age, sex, class, address, awareness about their CVD along with findings of ocular examination and results of colour vision testing. The demographic part of the questionnaire was filled by trained integrated eye care worker.

After receiving the filled questionnaire sheets, Snellen's chart was used to test the visual acuity at 6 metres distance. All children had normal near vision. Screening for colour vision was done using Ishihara pseudoisochromatic 38 plate edition which was administered to children by the principal investigator in a room with sufficient indirect natural tropical daylight in the morning hours. Examination was conducted in class rooms consisting of multiple wider windows with adequate bright light and with subjects sitting near the window side. The test was conducted based on the standard recommendations of colour vision testing.[9,10] All testing was done under binocular viewing conditions. The plates were held at arm length and tilted so that the plane of the paper was at right angles to the line of vision and set at eye level of the child. Before the test each child was instructed in the local language, fully understandable by the child. The first plate was presented first to check whether the child followed the instructions correctly. All children were active and responded within an average duration of 2 seconds per each test plate. Children who made more than five typical red-green defective responses between plates 2 and 21 were judged to have failed the test. Such children were then shown the diagnostic plates (22, 23, 24 and 25) to determine the type and severity of the defect. Those who failed the test were immediately re-tested and the result recorded.

Children who had deficient colour vision received necessary counselling and guidance regarding the condition, its prognosis, implication on future career, strategies to deal with it and minimize the probability of transmitting it to future generations. Furthermore, they were referred to a senior ophthalmologist to exclude any other associated visual problems.

Prior to data collection, ethical clearance was obtained from Institutional Ethical Committee of the University. Informed consent was obtained from parents or guardians of the children. The study adhered to the tenets of Declaration of Helsinki.

Data was analyzed using Statistical Package for Social Sciences (SPSS) Version 17 to calculate descriptive statistics (frequency and percentage) and apply tests of significance (x^2-test). p-values <0.05 were considered as "statistically significant". The 95% confidence interval (CI) was calculated using the confidence interval proportion calculator.

Results

Table 1 shows that of 850 children screened for CVD, 18 children (2.1%) had defective colour vision (95% confidence interval: 1.35-3.33). 16 of 432 males (3.7%), and 2 of 418 females (0.4%), were found to have congenital red-green CVD in the study. Of the 3.7% males found to have red-green defects, protans and deutans made up 1.1% and 3.7%, respectively, hence the deutan to protan ratio was 3:1. Of the 0.4% females found to show red-green defects, protans and deutans made up 0.2% each. Hence the deutan to protan ratio was 1:1.

Table 1: The percentage of phenotypic frequency of different types of CVD

Type of CVD	Total (n=850)		Male (n=432)		Female (n=416)	
	Number	Percentage	Number	Percentage	Number	Percentage
Protans	6	0.7	5	1.1	1	0.2
Deutans	12	1.4	11	2.5	1	0.2
Total (Red Green) CVD	18	2.1	16	3.7	2	0.4

p= 0.037

Table 2 represents the trend of colour vision defects. The overall trend of defects was: deuteranomaly> deuteranopia > protanomaly > protanopia.

Table 2: The percentage of phenotypic frequency of different types of CVD according to severity

Type of CVD	Total (n=850)		Male (n=432)		Female (n=416)	
	Number	Percentage	Number	Percentage	Number	Percentage
Protanomaly	4	0.47	3	0.69	1	0.2
Protanopia	2	0.23	2	0.46	0	0
Deuteranomaly	7	0.82	6	1.38	1	0.2
Deuteranopia	5	0.58	5	1.15	0	0
Total (Red Green) CVD)	18	2.1	16	3.7	2	0.4

Table 3 depicts that most children were not aware about CVD and only 2 (11.1%) children reported that they had difficulty in differentiating various colours. Of 18 children who had CVD, only 1 child reported that he had undergone eye examination at least once in his lifetime.

Table 3: Awareness about CVD

	Yes		No	
	Number	Percentage	Number	Percentage
Are you aware about any CVD?	1 / 18	5.5%	17 / 18	94.5%
Do you have difficult in differentiating various colours?	2 / 18	11.1%	16 / 18	88.9%
Have you undergone an eye examination atleast once?	1 / 18	5.5%	17 / 18	94.5%

Discussion

Screening of colour vision defects only require detection of presence of absence of a defect. Since the prevalence of protan and deutan defects are by far the highest amongst congenital colour deficiencies, most screening tests for colour vision only identify red-green deficiencies. Screening of colour vision deficiencies is usually done with pseudoisochromatic plates of which the Ishihara test is probably the most well-known. In 3 studies performed to evaluate the sensitivity of Ishihara pseudoisochromatic test, there was no evidence that Ishihara's test was less valid than any other screening tests.[11,12,13] It had mean sensitivity and specificity of 96% and 98.5% respectively.[14] It also showed good re-test reliability.[15] Therefore, in this study, we have used Ishihara's 38 plate edition, which is generally considered to be the most efficient for screening red-green congenital colour defects. Only one ophthalmologist interpreted the results, hence minimizing inter-observer variability.

This study provides a detailed description of colour vision deficiency for the first time among male and female children of Wardha District and thus provides the basic epidemiology and genetics of colour blindness in the region. The average prevalence of CVD was 3.7% in males and 0.4% in female children. Male children tend to have higher CVD frequency which reinforces the fact of X-linked recessive nature of the trait (i.e., the single X-chromosome in males is predominant to colour blindness, while females with two X-chromosomes can act as dosage compensation and decreases the risk of the disease).

Studies across India reveal similar prevalence of colour vision impairment among males and females (**Table 4**). However, studies among populations worldwide depict the significant variation in the prevalence. The frequency of red-green colour blindness among the male children of Nepal (3.9%),[21] Singapore (5.3%),[22] Thailand (5.6%),[23] Korea (5.9%),[24] Turkey (7.3%),[25] Iran (8.1%),[26] Jordan (8.7%)[27] were found higher than that of female children.

Table 4: Prevalence rates of CVD across India

Children	Total	Males	Females
Jammu and Kashmir[16]	4.38%	7.52%	0.83%
Patiala[17]	2.9%	3.85%	0.38%
Jodhpur[18]	3.2%	3.2%	0%
Pune[19]	2.02%	3.16%	0.40%
Andhra Pradesh[20]	4.07%	7.5%	0.3%
Our study	2.1%	3.7%	0.4%

The protan and deutan defects unmask the connotative use of colour in humans. The trend of colour vision defects in our study is as follows: deuteranomaly > deuteranopia > protanomaly > protanopia. Similar frequency trend of vision defects have been reported among different populations, highlighting the fact that green colour receptor is commonly affected more than red or blue colour receptors. The significance of normal vision involves absolute colour matching for many occupations.[30] In traffic signals, for deuteranope and protanope persons, the signals are less obvious, making handicap to perceive the signals. Moreover, the deutan

and protan individuals working with telecommunications and electric cables can recognize the blue and white wires but will be uncertain about the red, orange, brown and green.[7] Nearly 30% of people with abnormal colour vision report they have trouble judging the ripeness of fruit.[31]

Colour vision is integral to an individual's understanding of their visual world, and those with these defects can experience difficulties in everyday life. However, adaptive strategies and behaviours help to deal with potential difficulties they face in both their professional and personal lives. Early diagnosis of congenital dyschromatopsia would allow for minimization of these problems, improvement of adaptation of children to their dysfunction, and, most importantly, for better planning of their professional future.

Colour vision impairment being a genetic disorder, it is noteworthy to estimate the gene frequencies among populations for medical counselling purposes. Identification of colour deficient individuals among populations can help to stop or minimize the risk of transmitting the disorder to their offspring's by pre-conception or pre-marital counselling and also through prenatal diagnosis strategies.

The use of anomaloscope, the gold standard for confirming the diagnosis, classifying the types and determine the severity of CVD was beyond the scope of the present study considering the testing duration and its impractical portability to all the schools.

Particular strengths of this study is the fact that standardized colour vision testing was administered to the children by an ophthalmologist. Therefore, we believe our findings are likely generalizable to most children of Wardha District.

In conclusion, this was the first population-based study to define the prevalence of CVD in school children of Wardha District. Since most children were unaware about their impairment, screening of school children can be a simple and highly effective strategy in detecting colour vision impairment. Several occupations involve colour matching, due to which CVD patients may be handicapped in their job. Since, CVD is congenital, there is no permanent cure for it. However, advice at early age could help to find adaptive strategies, which enable to avoid disappointments in the choice of their future career. Parental education, awareness, genetic counselling strategies in the regions with high CVD incidence could help a lot in minimizing the occurrence of the disorder among their offspring.

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