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Original Article

To Study the Prevalence of Color Blindness among Adolescent (9th–12th Std.) Schoolchildren in Haldwani

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Abstract

Aims: This study aims to study the prevalence of color blindness among adolescent schoolchildren in Haldwani.

Study Design: A cross-sectional, investigator masked, clinical study was conducted on children.

Place and Duration of Study: This study was conducted at the Department of Ophthalmology Government Medical College Haldwani, Uttarakhand, between June 2018 and June 2020.

Materials and Methods: Students were called according to the roll number in a room. Clinical examinations of both eyes were done. Age and sex of the student were noted. The student was tested for color vision deficiency using Ishihara's type tests for color blindness, 38 plates edition. The color vision testing plates were held at 75 cm from the student and tilted at the right angle to the line of vision. The test was done in adequate lighted room resembling natural day light. Student was asked to read the numbers seen on the test plates and answer was noted down. The time given for telling the number on a plate was <5 s. Assessment of the reading of the plate determines the normality or defectiveness of color vision and also the type of color blindness. It was interpreted as per the instructions given on the booklet provided with Ishihara's type tests for color blindness so as to identify subject suffering from color blindness and also to differentiate the type of color blindness.

Results: The prevalence of color blindness was 202 (3.25%). Deuteranomaly was found among 189 (3.04%) and protanomaly among 11 (0.18%) subjects, deuteranomaly and protanomaly were found among 2 (0.03%) subjects. The prevalence of deuteranomaly was significantly more among males (4.38%) compared to females (1.58%).

Conclusion: This cross-sectional study was done to study the prevalence of color blindness among schoolchildren in Haldwani which included 6212 schoolchildren consisting of 52.2% of males and 47.8% of females. The prevalence of color blindness was found to be 3.25% with deuteranomaly was found among 3.04%, protanomaly among 0.18% of subjects, and combined deuteranomaly and protanomaly were found among 0.03% of subjects.

Key words: Color blindness, Protanomaly-deuteranomaly, Ishihara chart

INTRODUCTION

Color vision is the ability to discriminate a light stimulus as a function of its wavelength. Light with wavelength between approximately 380 and 760 nm causes photoreaction on human retina, which leads to vision. Various sensory and cognitive processes combine to result in the sense of color. Color vision is the capacity to discriminate a light stimulus as a function of its wavelength. Light with wavelength between 380 and 760 nm causes photoreaction on the retina, which leads to visual perception in humans. The sense of color is perceived from the combination of various sensory and cognitive processes.[1,2]

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The description and appreciation of colors depend on the ability of receptors in retina, that is, rods and cones. Rods are mainly responsible for black and white vision, whereas cone systems are mainly responsible for color vision. The Young Helmholtz theory of color vision in human

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postulates the existence of three kinds of cones, each containing a different photo pigment and more sensitive to one of the three primary colors. Only one of the three types of color pigments is present in each of the different cones. The color pigments are called blue-sensitive pigment, green-sensitive pigment, and red-sensitive pigment showing peak absorbencies at light wavelength of 445, 535, and 570 nm, respectively.[3,4] Red, green, and blue are thus called primary colors as any color can be produced by mixing appropriate proportion of red, green, or blue color.[5]

Dyschromatopsia is due to the deficiency of mechanism to perceive color. It has been classified into anomalous trichromatism and dichromatism. Anomalous trichromatism is a form of defective color vision. The terms protanomalous (red), deuteranomalous (green) and tritanomalous (blue) respectively represent the corresponding pigment anomoly.[6]

Dichromatism, the ability to perceive one of three primary colors, is absent. If red color is absent, it is called protanopia. Complete defect for green color is called deuteranopia. In the same way, the absence of blue color is called tritanopia.[7] Cardiovascular disease (CVD) most commonly affects the males, because of recessive trait linked to the X chromosome.[8]

The Ishihara color test is most widely used as the screening test of red-green color deficiency. In Indians, the prevalence was 3.69% in males and 1.04% in females.[9] Among 8–10% of Caucasians, male population was found to affected by red-green color blindness due to congenital protan and deuteran defects.[10]

According to Pease,[11] occupation in the armed forces, aviation, electrical, railways, roadways, and marines has color standard required for employment, while other professions, such as geology, graphic designs, and health-care professions,[12] require normal color vision for effective, efficient, and safe performance. Bacon[13] found that the color differentiation was needed for teaching and learning chemistry, physics, and biology in secondary school. Gordon[14] suggested that CVD affects the activities of children in school, leading to some psychological effect. It is, therefore, important that children know of their color vision status, be advised on how to deal with the condition, and what profession they might choose not to face occupational difficulties.

The Ishihara color test is a test to determine if a patient has color blindness. Hence, it is important to look at the prevalence of color blindness in children and identify the problems associated with it. Keeping the above aspects in mind, the following study has been carried out to find out the prevalence of color blindness in schoolchildren and to make parents and their teachers aware of this disease so that they can modify their teaching methods and choosing and adjusting with suitable profession

MATERIALS AND METHODS

This cross-sectional study entitled "To Study the Prevalence of Color Blindness among Schoolchildren (9th–12th) in Haldwani" was conducted after clearance from Board of Studies and Ethical committee in the Department of Ophthalmology, Dr. Sushila Tiwari Government Hospital, Haldwani, Nainital, during the period of 2018–2020.

Ethical Consideration

Approval from the Institutional Ethical Committee and permission from principal was taken to conduct the study. Informed consent was taken from all the students.

Sample Size

The study population has been calculated using G-power software with 80% of the power and 5% of the significance level. The total sample size was determined to be.

The sample size was calculated using the following formula:
Sample size = 4pq/d2.
P = 8%.
Q= (1−0.08).
D = 20% relative error.
Sample Size = 1150.
Design Effect =2.
1150*2 = 2300.
10% Non-response rate.
Sample size = 2300 + 230 = 2530.
Total schools = 30.

A total of 2530 out of 30 schools by simple random sampling.

Eighty-five students from each school by SRS.

Sample Technique

The sampling technique used was simple random sampling.

Inclusion and Exclusion Criteria

The study subjects were chosen as per the inclusion and exclusion criteria:

Inclusion criteria

1. Healthy students with normal ocular examination findings.
2. Students should be in the age group between 13 and 18 years.
3. Students willing to participate in the study

Exclusion criteria

The following criteria were excluded from the study:

1. Head injury which significantly affects vision.
2. Chronic drug therapy (more than 1 month)
3. Eye diseases.

Study Procedure

After approval from the Institutional Ethical Committee, all patients were selected as per inclusion and exclusion criteria. A detailed history, complete physical examination, and routine and appropriate investigations were done for all patients.

Students were called according to the roll number in a room. Clinical examinations of both eyes were done. Age and sex of the student were noted. The student was tested for color vision deficiency using Ishihara's type tests for color blindness, 38 plates edition.

The color vision testing plates were held at 75 cm from the student and tilted at right angle to the line of vision. The test was done in adequate lighted room resembling natural day light. Student was asked to read the numbers seen on the test plates and answer was noted down. The time given for telling the number on a plate was <5 s.[10] Assessment of the reading of the plate determines the normality or defectiveness of color vision and also the type of color blindness. It was interpreted as per the instructions given on the booklet provided with Ishihara's type tests for color blindness so as to identify subject suffering from color blindness and also to differentiate the type of color blindness.

Early detection of color vision abnormality and its associated problems in children allow parents and teachers to make appropriate adjustment in teaching methods or to take other available measure for the benefit of student. Furthermore, color blind person may found it difficult to work in certain professions which require proper color perception such as traffic policeman, railway driver, and technicians in color industries.

Out of 38 plates, plate numbers 1–25 were used in the present study. The types of color blindness were differentiated with the help of key provided with the chart. According to it, the first plate was presented first to check whether they followed instruction correctly or not. Students who made more than five typical red-green defective responses between plates 2 and 21 were decided to have failed the test.[11,12]

Thereafter, diagnostic plate numbers 22–25 were used to determine the precise type and severity of color vision defects. Those who failed the test were immediately retested and result was noted down in pro forma. List of students suffering from color vision impairment was given to the teachers which they would be asked to inform to respective parents regarding their problem and special care. In this study anomaloscope, the gold standard in color vision test was not used to confirm the diagnosis, further classify the types, and determine the severity of CVD. The instrument was not available in our set up. Of course, the Ishihara test with 38 plate edition has been reported to have high sensitivity and specificity in identifying red-green color vision defects.

Statistical Analysis

The data were entered into the Microsoft Excel and the statistical analysis was performed by statistical software SPSS version 21.0. The quantitative (numerical variables) was present in the form of mean and SD and the qualitative (categorical variables) was present in the form of frequency and percentage.

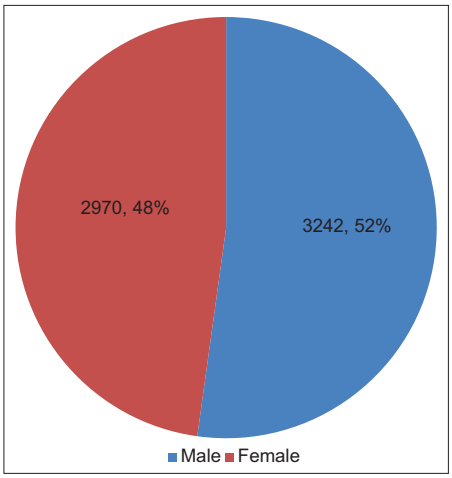
The Student's *t*-test was used for comparing the mean values between the two groups, whereas Chi-square test was applied for comparing the frequency. *P*-value was considered to be significant when <0.05.

RESULTS

Gender

The study population consisted of 3242 (52.2%) males and 2970 (47.8%) females.

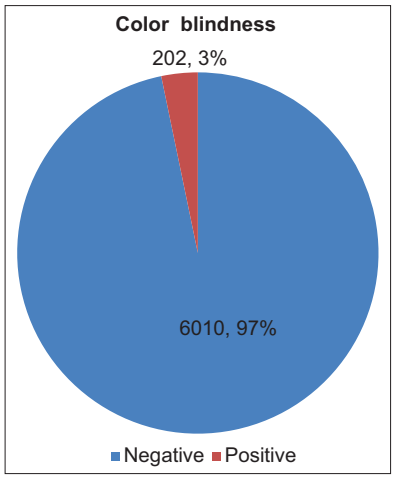
Gender	Frequency	Percent
Male	3242	52.2
Female	2970	47.8
Total	6212	100.0

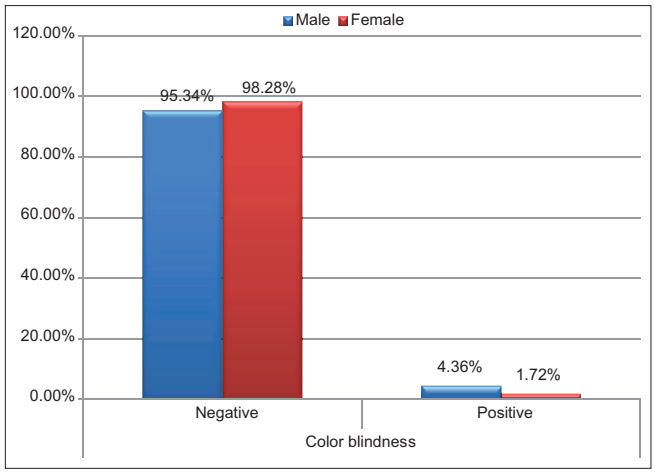


Prevalence of Color Blindness

The prevalence of color blindness was 202 (3.25%).

Color blindness	Frequency	Percent
Negative	6010	96.75
Positive	202	3.25
Total	6212	100.0

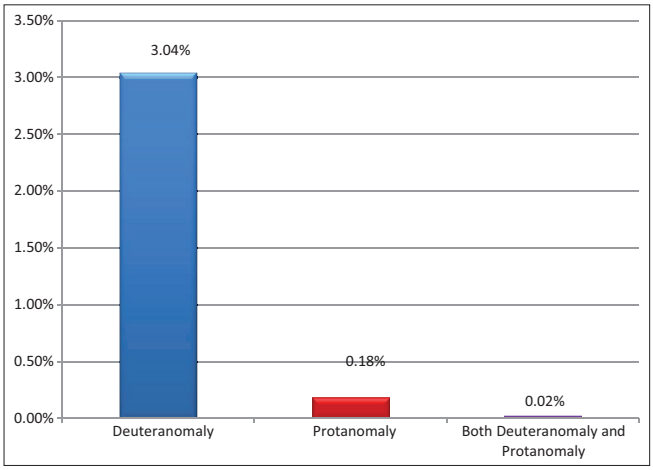




Type of Color Blindness

Deuteranomaly was found among 189 (3.04%) and protanomaly among 11 (0.18%) subjects, deuteranomaly and protanomaly were found among 2 (0.03%) subjects.

	Number	Percentage
Deuteranomaly	189	3.04
Protanomaly	11	0.18
Both deuteranomaly and protanomaly	2	0.03



Prevalence of Deuteranomaly in Genders

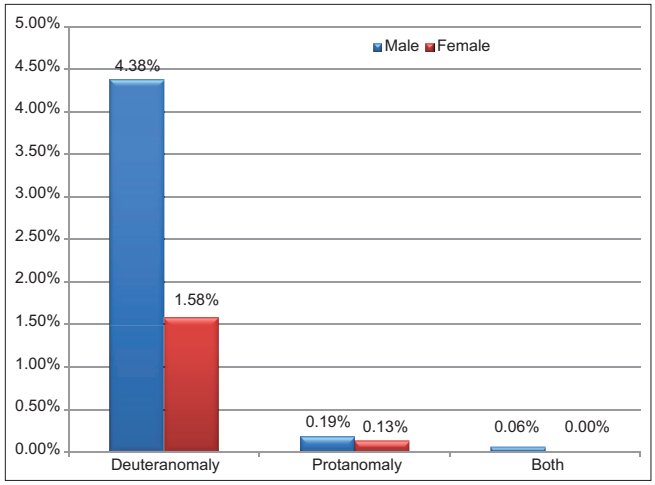
The prevalence of color blindness was compared between males and females using the Chi-square test. The prevalence of color blindness was significantly more among males (4.6%) compared to females (1.7).

	Gender		Total
	Male	Female	
Negative	3091	2919	6010
	95.34%	98.28%	96.75%
Positive	151	51	202
	4.66%	1.72%	3.25%
Total	3242	2970	6212
	100.00%	100.00%	100.00%

χ^2 value=41.911, P<0.001*

The prevalence of deuteranomaly was compared between males and females using the Chi-square test. The prevalence of deuteranomaly was significantly more among males (4.38%) compared to females (1.58%).

	Gender		χ^2 value	*p*-value
	Male	Female		
Deuteranomaly	142	47	37.477	< 0.001*
	4.38%	1.58%		
Protanomaly	7	4	0.579	0.447
	0.19%	0.13%		
Both deuteranomaly and protanomaly	2	0	1.832	0.176
	0.06%	0.00%		



DISCUSSION

This study presents a detailed description of color blindness for the 1st time among male and female primary and high school students in Haldwani, and thus provides the basic epidemiology of color blindness in this region.

Color vision deficiency assessments enable patients to follow the adaptive strategies that could minimize the

risks associated with the disorder. Testing was done using the Richmond Hardy-Rand-Rittler (HRR) test, which is generally considered to be efficient for screening congenital CVD. In addition, the HRR test can reliably detect, categorize, and grade the severity of the protan, deuteran, and tritan color vision deficiencies.[15] The Richmond HRR is, therefore, not only a useful and simple diagnostic device but it also has sufficient sensitivity and specificity to allow investigators to use the results in a clinically meaningful way.[16]

Prevalence

Different prevalence of congenital CVD was reported in literature in different population around the world.[17] In our study, the prevalence of color blindness was found to be 3.2%. This was similar to the studies by Rajkumar *et al*.,[18] the prevalence of color blindness was 3.2% among children aged 10–17 years, Agrawal *et al*.,[19] the prevalence of red-green color deficiency was found to be 3.3%, Wale *et al*.[20] found that the prevalence of color blindness among 850 schoolchildren was found to be 4.24%, Woldeamanuel and Geta,[12] the prevalence of color vision deficiency was 4.1%, which is also nearly similar with the prevalence rates reported in the previous studies.[21] This finding was also comparable with a study done in Thailand, which reported a prevelence of 3.8% among Nigerian male secondary school students studying in Thailand.[22]

Higher prevalence was reported in a study from Singapore,[23] the prevalence of color blindness among Chinese (5.4%), Malay (4.9%), and Indian (4.9%). John *et al.* concluded that the prevalence of CVD in preschool boys varies by ethnicity, with the highest prevalence in non-Hispanic White and lowest in Black children.[24] A higher prevalence of 5.28% was reported in India among Manipuri Muslims of both sexes.[25]

The prevalence of CVD was lower in the study by others be 2.3% reported in Ibadan, Southwest Nigeria, 1.5% found in Zaria, North Nigeria,[26] and 2.6% reported in Port Harcourt, South Nigeria.[14] Ethnically based studies that were conducted in Asia, Europe, and Oceania reported higher prevalence of CVD than the current study, which could be due to racial differences. This suggests that CVD varies among races and geographical regions of the world.

Gender Distribution

In the present study, the prevalence of color blindness was significantly more among males (4.6%) compared to females (1.7%). This coincided with the findings by Woldeamanuel and Geta, the percentage of color vision deficiency was higher among boys (3.6%) as compared to girls (0.6%) and Agarwal and Bansod[27] observed that the prevalence of color blindness among boys was 4.66%. Reddy *et al.* also observed that the prevalence of color blindness in boys was 3.3% in compared to 8% prevalence rate in males among Caucasians in Europe, Great Britain, and the United States,[28] but it is similar to 3–4% prevalence rate of color blindness in the Indian population,[29] 3.3% prevalence rate in male schoolchildren in Guntur.[30] Whereas it is slightly more than the lowest prevelence rate of 2% observed in North America, South America, Fiji and in certain Asian Indian tribes.[31] Wale *et al*.[32] reported that there was a highly significant association between sex and color blindness (adjusted odds ratio = 3.19).

Type of Color Blind Anomaly

In the current study, deuteranomaly was found among 3.04%, protanomaly among 11 (0.18%) subjects, and combined deuteranomaly and protanomaly among 0.03% of subjects. This was in accordance with the study done by Bowmaker,[33] indicated that the most common form of anomalous color vision is deuteranomaly and Woldeamanuel and Geta,[34] most of the color blind children were deuteran. In line with this finding, a high frequency of deuteran as compared to protan defects was observed in other studies.[35] It was suggested that green color receptor is commonly affected than other cone receptors.[36]

The ratio of deuteranopia to protanopia in this study is 2.3:1 as compare to 4.3:1.55 reported by Oriowo[37] and 2.4:0.8 reported by Rajkumar *et al*.[38] The ratio of deuteranopia to protanopia among Saudi in this study is 2.02:0.59 as compare to ratio among non-Saudi 3.23:2.25.

Prevalence of Anomalies among Males and Females

In the current study, the prevalence of deuteranomaly was significantly more among males (4.38%) compared to females (1.58%). Both deuteranomaly and protanomaly were more among males compared to females with no significant difference between them.

This was in accordance with the results by Reddy *et al*., Agarwal and Bansod, there were 11 boys with color blindness include 10 boys with deuteranomaly (i.e., 2.87%) and 1 boy with protanomaly (0.29%). Furthermore, the only girl with color blindness was found to be suffered from deuteranomaly, Moudgil *et al*.[39] on his study among 55 protanopes, 51 were male and 4 were female. Deuteranomaly was observed in six students, of which, four were male and two were female and Shah *et al*.[40] all types of color blind anomalies were more among males than females. It is suggested by several researchers that green color receptor is commonly affected more than red or blue color receptors. This finding is in agreement to several researches.

Color 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 behaviors help to deal with potential difficulties they face in both their professional and personal lives.[41]

In this condition, color blind schoolchildren must be given career advice which includes information as to which career they may find to be difficult or impossible to follow and also help schoolchildren by preventing them from struggling in the classroom due to lack of awareness of the possible effects of their disability by both their parents and teachers. Teachers in the schools must be strictly allowed to give training for the task of color blindness or on how to treat color blind children in a school environment.[42]

Education, screening, and prenatal counseling for the disease in these areas could help a lot in minimizing the occurrence of the disorder and help them to make informed choices and avoid the birth of children with color blindness. Moral support from the family and society is required for the healthy development of mental status of the individual suffering from this disorder. Government should also make certain policies and programs regarding career choices and jobs for color blind individuals.

CONCLUSION

This cross-sectional study was done to study the prevalence of color blindness among schoolchildren in Haldwani which included 6212 schoolchildren consisting of 52.2% of males and 47.8% of females.

The prevalence of color blindness was found to be 3.25% with deuteranomaly which was found among 3.04%, protanomaly among 0.18% of subjects, and combined deuteranomaly and protanomaly were found among 0.03% of subjects.

The prevalence of color blindness was significantly more among males (4.6%) compared to females (1.7%). Furthermore, the different types of anomalies were significantly more among males compared to females.

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