Prevalence of color blindness in school children at Mansoura district, Egypt.

Omaima Megahed, Hossam Abouelkheir, Waleed Abou Samra, Eglal ElSaeid

Department of Ophthalmology, Faculty of medicine - Mansoura University

*Corresponding author: Omaima Megahed, Mansoura Ophthalmic Center, Mansoura University, Mansoura, Egypt, **Mobile: 01060953691, E-mail: Omaymamohammed66@gmail.com**

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Short title: Prevalence of color blindness in school children

Abstract

Purpose: This study aimed to screen color vision deficiency in school children at Mansoura schools, Egypt. And to evaluate the state of awareness regarding their anomaly

Patients and methods: This was a descriptive cross sectional observational study included 1106 students aged from 10 to 15 years old underwent visual acuity examination by Landolt broken ring chart, contrast sensitivity examination by Pelli Robson contrast sensitivity chart and color vision examination by both Ishihara book and Farnsworth-Munsell D-15 hue test.

Results: This study showed that the prevalence of color vision deficiency in school children aged from 10 to 15 years old is 2% of the total students and it is more common an males (2.4%) than females (1.3%). We found the most common type is equal deficiency of both red and green followed by protanomaly, deutranomaly and deuteranopia. We found no cases of tritanomaly or total color blindness. There is no clinically significant relationship between color vision deficiency and age group and also there is no clinically significant relationship between color vision deficiency and Contrast sensitivity. All students with color vision deficiency in our study were unaware of their color vision defect.

Conclusion: This study reveals that the occurrence of color vision deficiency among the students in Mansoura district was 2%, with males having a noticeably higher prevalence than females. The majority of cases exhibited equal deficiency in both red and green, followed by a mild protan, and then an equal percentage of both mild and severe duetan forms.

Key words: Color vision deficiency, protanomaly, deutranomaly, deutranopia.

INTRODUCTION

Normal color vision is trichromatic and three classes of photo pigments (opsin proteins) vary in their spectral sensitivities and are controlled by genes. Red and green opsins have 96% similarity; on the other hand they have only a 46% similarity with the blue opsin[1].

Colour vision defects (CVDs) are the inability to perceive color differences under normal lighting conditions. It is one of the commonest disorders of vision and divided into congenital and acquired forms. Congenital CVDs are the most frequent X-linked genetic disorder in humans, inherited non-pathologic, permanent, bilateral and stationary. Acquired forms of color vision deficiency are rare and induced by pathology as macular degenerations or optic neuropathy[2].

The National Institutes of Health (NIH, 2015) indicate that the most common form of congenital color vision deficiency is the "anomalous red-green" type (protanomaly and deuteranomaly, reduced sensitivity to red and green light, correspondingly)[3].

In addition, CVDs doesn't cause complete blindness and there is no available therapeutics which could manage CVDs. On the other hand, a high proportion of school children are unaware of their color vision condition and undiagnosed CVDs could pose a handicap to the scholarly performance of an affected student[4]. In addition, early determination of color vision malfunction among children allows parents and teachers to make essential adjustments to the teaching approaches for proper learning[5].

In different areas of the world, the prevalence of congenital color blindness is different. For instance, 8% of men and 0.4% of women in Western countries are color blind. Congenital color vision deficiency prevalence is 4-6.5% in Japan and China, 4% in African nations, 7.3% in Turkey, and 2.9-11% in Saudi Arabia[6].

The UK Health advises that certain jobs are required normal color vision with a view to product safety or quality. Safety For a blind person in color is at risk in certain professions, such as the military, rail, merchant shipping, rail, navigation, Civil aviation, hospital engineer, pharmacist, police and fire department, etc. Service Quality Will be compromised in some jobs, such as textile color matching, printing and coloring, chemical Color-based analysis, horticulture, fine arts, and color photography etc[7].

Additionally, there is limited robust scientific evidence regarding CVDs among Indian populations. With the absence of standardized guidelines in our country, parental education, awareness, genetic testing, and counseling plans in areas with high CVD prevalence could assist children and their families in managing the condition and planning their respective professional futures. It is suggested that, given the rapid advancements in children's educational requirements, which currently lean more towards color-based learning, the government should strive to develop policies and guidelines for comprehensive school eye health programs to screen children for CVDs[8-9].

So, it is interesting to determine the prevalence of congenital CVDs in school children in our district (Mansoura), Egypt to increase awareness of their parents and teachers regarding their anomaly.

PATIENTS AND METHODS

This was a descriptive cross sectional observational study that was conducted to evaluate prevalence of color vision deficiency in Mansoura schools & study the relationship of CVD with all of the following:

(Certain age groups, Gender, Visual acuity, glass wearing and Contrast sensitivity). And the most important goal was evaluation of the state of awareness of the students and their parents regarding their anomaly.

It was performed on 1106 students aged 10 to 15 years old, whose parents agreed to the examination in writing after ruling out any ocular pathology, ocular trauma, systemic disease, or medication use.

The study protocol was approved from the institutional review board (IRB) NO: MS.22.03.1926 of Mansoura Faculty of Medicine. An informed written consent was obtained from the parents' of the students after explanation of the aims, methods of our study.

All students were subjected to a full history taking and ophthalmic examination was done including UCVA using Landolt broken c chart. All students who had spectacles were had their visual acuity assessed while wearing spectacles. Students with decreased visual acuity were being referred to tertiary referral center for refraction.

Contrast sensitivity test was done in a place with good daylight illumination using Pelli Robson contrast sensitivity chart. The Pelli-Robson score is a logarithmic measure of the subject's contrast sensitivity. Thus, a score is classified as the following: (Leat et al., 2009)

- Score of 2.0 = Normal contrast sensitivity of 100% (Reading at least two or three less contrasted letters perfectly)
- Score of less than 1.5= Visual impairment (poor contrast sensitivity)
- Score of less than 1.0= Visual disability (impaired contrast sensitivity)

Students with decreased contrast sensitivity were referred to tertiary referral center for further investigations for any ocular problems.

The color vision test was done using Ishihara pseudo isochromatic plates. Before performing the test, the approach was clearly clarified to all individuals. The plates were viewed in a well-lit room with daylight. Using direct sunlight or electric light may affect the colors. The plates were held 75 cm away from the subject and tilted so that the paper is perpendicular to the line of sight. The test was performed to each eye on its own then both eyes binocularly. The correct position of each plate was indicated by a printed number on the back. The numbers on plates 1-17 were given and responses were given within three seconds.

Evaluation of the readings of plates 1 to 15 determines the normality or defectiveness of color vision. If 13 or more plates are read normally, the color vision is regarded as normal. If

only 9 or less than 9 plates are read normally, the color vision is regarded as deficient. A pass of the Ishihara test was the ability to read all plates or an incorrect response in not more than two plates correctly. The results were classified based on the instructions described in the attached manual of Ishihara's test plates. The results were submitted to their teachers for possible use in their career-orientation program. Similarly, the parents were counseled about the implications of the results on future career options of the affected students.

Students who failed the Ishihara plates had additional evaluation with the Farnsworth Munsell D-15 hue test under daylight illumination following standard instructions to detect and confirm the type and severity of color vision deficiency. A patient with a CVD arranged the color discs in a different order than a person with normal color vision. The test was done binocularly. Each student was given adequate time to complete arrangements of colors discs on one tray containing 15 removable color reference caps. The results were interpreted according to each student's graph and score to detect type and severity of color vision deficiency. After performing both tests, the students who fail the Ishihara test were referred to tertiary referral center to dilate their fundus to check for optic neuropathy, maculopathy or other gross retinal pathologies.

Statistical analysis

Data were analyzed using the Statistical Package of Social Science (SPSS) program for Windows (version 24). The normality of data was first tested with one-sample Kolmogorov-Smirnov test.

Qualitative data were described using number and percent. Chi square test was used to compare qualitative variables while Monte Carlo test was used to compare qualitative variables when expected count less than 5. The results was considered significant when $p \leq 0.05$.

RESULTS

After taking a full history and ruling out any ocular pathology, ocular trauma, systemic disease, or medication, 1106 students were tested for visual acuity, contrast sensitivity by pelli robson chart, and color vision by ishihara book and Hue D15 test.

In table (1) 98% had normal color vision & 2 % had color vision deficiency distributed as 0.9% had equal deficiency of both red and green, 0.2% were protanomaly, 0.2 % were deuteranopia, 0.7 % were deuteranomaly and all of the other types of CVD were 0%. The prevalence of CVD among the students was 2 %.

Table (1): Prevalence of color blindness among school children.

Diagnosis	The studied group (n=1106)	
	no	%
Normal	1084	98.0
Deficiency of both red and green	10	0.9
protanomaly	2	0.2
Deuteranopia	2	0.2
deuteranomaly	8	0.7
Protanopia	0	0.0
Tritanopia	0	0.0
Tritanomaly	0	0.0
Total color blindness	0	0.0
Normal	1084	98.0
Color blindness	22	2.0

Table (2) shows that there is a significant difference between the severity of CVD and types of CVD.

Table (2): Distribution of severity according to types of CVD.

	Mild	Moderate	Severe	P value
Equal deficiency of both red green (n=10)	10 (100%)	0 (0%)	0 (0%)	**≤0.001***
Deutranomly (n=8)	3 (37.5%)	5 (62.5%)	0 (0%)	
Deutranopia (n=2)	0 (0%)	0 (0%)	2 (100%)	
Protanomly (n=2)	1 (50%)	1 (50%)	0 (0%)	

Monte carlo test was used , * significant p value ≤0.05

Table (3) shows the distribution of CVD in different age categories and also shows that there is no significant difference between age and CVD as we found that 45.5 % of age group (10-12 y) & 36.4 % of age group (12-14 y) & 18.2% of age group (15y) were have color vision deficiency.

The same table also shows that CVD was prevalent among males as 72.7 % of students having color vision deficiency were males, and there is a significant difference between CVD and gender.

The prevalence among CVD students was 2.4% males & 1.3% females.

Table (3): Association between color blindness and demographic data.

Demographic data	Normal (n=1084)	Color blindness (n=22)	Test of significance	P value
Age (years)				
10-12 y	646 (59.6%)	10 (45.5%)	χ^2 =1.79	0.409
12-14 y	290 (26.8%)	8 (36.4%)		
15 y	184 (13.7%)	4 (18.2%)		
Gender				
Male	444 (41.0%)	16 (72.7%) (2.4%)	χ^2 =8.95	**0.003***
Female	640 (59.0%)	6 (27.3%) (1.3%)		

χ^2 : Chi square test , * significant p value ≤0.05

The table (4) shows the relationship between color vision deficiency and visual acuity is of no significance

Table (4): Association between color blindness and visual acuity

Contrast	Normal (n=1084)	Color blindness (n=22)	Test of significance	P value
RT eye				
<0.3	965 (89.0%)	22 (100%)		
0.3-0.47	62 (5.7%)	0 (0%)	MC	0.382
0.6-0.77	28 (2.6%)	0 (0%)		
1	29(2.7%)	0 (0%)		
Left eye				
<0.3	953 (87.9%)	22 (100%)		
0.3-0.47	80 (7.4%)	0 (0%)	MC	0.292
0.6-0.77	26 (2.4%)	0 (0%)		
1	25 (2.3%)	0 (0%)		
MC: Monte carlo test , p value not significant >0.05				

The table (5) shows the relationship between color vision deficiency and contrast sensitivity is of no significance

Table (5): Association between color blindness and contrast results

Contrast	Normal (n=1084)	Color blindness (n=22)	Test of significance	P value
Normal	870 (80.3%)	14 (63.6%)		
Poor	192 (17.7%)	8 (36.4%)	χ^2 =5.34	0.069
Impairment	22 (2.0%)	0 (0%)		
χ^2 : Chi square test , p value not significant >0.05				

(Normal contrast sensitivity =2.0, Poor contrast sensitivity <1.5,Impaired contrast sensitivity <1.0)

The distribution of awareness of the students and their parents regarding their anomaly was 100%.

DISCUSSION:

Color vision deficiency is a condition characterized by the inability to perceive differences in color. It can impact your child's performance in school or on the sports field and affect their confidence from an early age. In adults, having CVD can affect career choices and be a disappointing condition to live with. Early diagnosis is crucial for well-being as it allows for support in school and at home, and helps individuals learn when to ask for help[9-10].

CVD is classified into two main categories; inherited color vision defects, also known as color vision deficiencies (CVD), are relatively common among individuals and acquired CVD that results from persistent illness, traumatic injuries, medications, exposure to chemicals or normal aging process[11].

According to reports, the majority of people with color vision defects go undiagnosed. As a result, the under-reporting of color vision deficiency in the general population is attributed to a lack of awareness and the absence of adequate screening methods[12].

A comprehensive medical history and ocular examination of students with CVD yielded normal results in the current cross-sectional observational study, which aimed to study the prevalence and types of CVD among school children in Mansoura. As a result, it is possible that the cause of color vision impairment in these individuals is congenital, as we aimed to investigate the prevalence and types of color vision deficiency in school students aged 10-15 years.

In our research, we discovered that the prevalence of CVD is 2%. This prevalence is similar to the findings of ***Shrestha et al. (2010)*** which reported a prevalence of 2.1%[12]. the variability in CVD prevalence observed in our study may be

attributed to differences in the study groups, geographical areas, and ethnicity.

In the present study, there were 646 males (58.4%) and 460 females (41.6%). We discovered that the prevalence of color vision deficiency (CVD) among males was 2.4% (16 cases); while among females it was 1.3% (6 cases). We observed a statistically significant correlation between gender and color vision deficiency. It was found that a higher number of males had CVD compared to females (p = 0.003), which could be attributed to the x-linked inheritance pattern of the deficiency[9].

In consistent with our results, ***Karim and Saleem (2013)***[13] with a total of 1856 participants, including 1275 males and 581 females found it 8.47 % in males and 1.37 % in females. While ***Niroula and Saha (2010)***[12] shows that Among 474 boys, 18 boys were color blind with the prevalence of 3.8%. None of girls were found to be color blind.

In the present study, the distribution of CVD was consistent among the age groups (10-12: 45.5%, >12-14: 36.4%, >14-15: 18.2%). Although this indicates a decline in the occurrence of the defect as age increases, the difference was not found to be statistically significant (p = 0.409). Since CVD is an inherited defect, the prevalence across various age groups is statistically insignificant (p > 0.05).

Although ***Mashige and Van Staden (2019)***[15] discovered that the distribution of CVD varied across age groups (7-12: 1.8%, 13-17: 2.7%), indicating an increase in defect prevalence with age, the difference was not statistically significant (p = 0.12).

In the present study, the prevalence of various types of color vision deficiency among all students was as follows: equal deficiency in both red and green (0.9%), deuteranomaly (0.7%), protanomaly (0.2%), deuteranopia (0.2%) and all of the other types of CVD were 0%.

The most common type of color vision deficiency was equal deficiency in both red and green which is first discovered in our study which may be due to equal defects with the OPN1LW (red pigment cone) and OPN1MW (green pigment) genes as a result of genetic mutations.

The distribution of different types of color vision deficiency among color deficient students is as follows: equal deficiency in red and green (45.4%), deutranomaly (36.3%), protanomaly (0.09%), and deutranopia (0.09%). According to Geletu et al, the prevalence of deuteranomaly was 48.5%, deuteranopia was 21.2%, and protanomaly was 18.4 %[16].

Congenital tritanomaly is considered rare, with a prevalence of 0.0001 as documented in the study by Adams Aj et al. However, in the current study, a prevalence of 0% was found also No cases of total congenital color deficiency were found in our study, confirming its rarity[17].

But according to Radwan et al., 2015 the stratification of color vision deficiencies types in different stages of DR showed gradual increase in both tritanopia and combined color vision deficiency in NPDR with progression of DR stages with total color blindness appearing only in PDR[18].

El Moussawi et al., 2021a[20] reported that poor visual acuity is more commonly observed in cases of monochromacy or total color blindness although in our study, there was no significant association between CVD and wearing glasses or poor visual acuity.

In our study we were interested in studying the relationship between CVD and contrast sensitivity and we found that there was not statistically significant (p=0.069).

All students with CVD in our study were unaware of their color vision defect. ***Woldeamanuel and Geta (2018)***[21] also reported that the majority of CVD students were unaware of their color vision status. To increase awareness about color vision deficiencies, schoolchildren should undergo color vision screening.

However, this study has some limitations that may be due to school choice rather than a population-based sample, and this might not provide complete analysis or a true reflection of the nation-wide's population. Also, the majority of study participants did not have the chance for a detailed eye examination to get more data.

CONCLUSION:

According to our findings, the prevalence of CVD among students in the Mansoura district is 2%, with males having a noticeably higher prevalence than females. The majority of the cases had equal red and green deficiency, followed by a deuteranomaly, and then an equal percentage of both protanomaly and deuteranopia forms. There are no students who have tritanomaly or are completely colorblind. Our findings also show that there is no link between CVD and

visual acuity or contrast sensitivity. None of the students with CVD or their parents were aware of their condition.

Recommendations:

A more frequent screening for color vision deficiency in school children at Mansoura schools, Egypt to increase the state of awareness regarding their anomaly.

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Data Availability: The authors declare that all data supporting the findings of this study are available within the article and its supplementary information file.

Competing interests: The authors declare no competing interests.

Corresponding author

Correspondence to: Omaima Megahed

Email: Omaymamohammed66@gmail.com

Affiliations

Omaima Megahed. Resident of ophthalmology, Mansoura Ophthalmic Hospital, Egypt, Daqahlia governorate, Egypt.

Ethics declarations: All procedures performed in the study followed the 1964 Helsinki declaration and its later amendments, University Ethics Committee approved the project.

Conflict of interest

Omaima Megahed, Hossam Abouelkheir, Waleed Abou Samra, Eglal ElSaeid. All authors have no conflicts of interest that are directly relevant to the content of this review.

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