

Research Article

Prevalence of Color Blindness among Students of four basic schools in Koya City

Harem Othman Smail*, Evan Mustafa Ismael and Sayran Anwer Ali

Department of Biology, Koya University, University Park, Danielle Mitterrand Boulevard, Koysinjaq, Kurdistan Region –Iraq.

Abstract: Color blindness or color vision deficiency is X-linked recessive disorder that affects males more frequently than females. Abnormality in any one or all three cone photoreceptors caused Congenital disorders. Protanopia, deuteranopia results when long wavelength (L), photopigments (red), middle wavelength (M) and photopigments (green) are missing.

This cross-sectional study was done to find out the prevalence of color vision deficiency among basic school students in Koya city with different ages and genders. The study was conducted in four basic schools that were present in Koya city (Zheen, Zanst, Nawroz and Najibaxan).

All students screened by using Ishihara 24 plates. For the study (n=400, male=206, female=194, age=8-14) were selected & examined. The result revealed that the prevalence rate of the deficiency in four primary schools 3.39% (7) in males and 0% females. The study concluded that color blindness is different between students in each school, cannot find the prevalence of Color blindness in females in each school and affects males more than females because color blindness is an X-linked recessive disorder. The aim of the study was to determine the prevalence of color blindness in some basic schools in Koya city, Kurdistan Region/ Iraq.

Keywords: Color blindness, Prevalence, Pseudoisochromatic Ishihara color test, X-linked recessive disorder, Opsin.

1. Introduction

Color blindness or color vision deficiency (CVD) is the decreased ability to see some colors or perceive their differences [1]. It takes place when one or more of three types of color sensitive cone cells or photoreceptor (red, green and blue) do not perfectly gather or send the proper color signals to the optic nerve. It may either be congenital or acquired. The congenital type usually inherited and linked to the X chromosome (red-green color blindness) and therefore, more frequent in males than females, besides it may be commonly an autosomal dominant trait (blue-yellow color blindness) and very rare an autosomal recessive inherited trait [2].

Normal color vision is actually trichromatic that is the combination of red, green, and blue lights [3]. It requires three types of cone photopigments that differ in their relative spectral sensitivities, and are generally termed as red (long wavelength), green (middle wavelength), and blue (short wavelength) cone pigments [4]. There are three types of color vision deficiency: monochromacy, dichromacy and anomalous trichromacy.

Monochromatism, being so rare, is the total absence of color vision and occurs when two or all three of the cone pigments are missing. Dichromatism occurs, when only one of the cone pigments is missing and is categorized into protanopia (characterized by the utter absence of red cone), deuteranopia (characterized by the absence of green cone) and tritanopia (complete absence of blue cone). Anomalous trichromatism involves reduced sensitivity to one of the three cone pigments and includes protanomaly, deuteranomaly and tritanomaly in which the spectral sensitivity of the red, green and blue cone receptors is altered. Achromatopsia is the most dangerous form of color vision defect [5].

In 1986, Nathans and colleagues isolated and sequenced the genes, encoding the human long wavelength (L), middle wavelength (M) and short wavelength (S) cone opsins and took the first steps toward testing the long-held, two-part hypothesis that (1) variation in the amino acid sequences of the cone opsins are responsible for the spectral differences among the photopigments, that all share the same 11-cis-retinal chromophore, and (2) alterations in the cone opsin genes underlie inherited color vision deficiencies. Findings

from these studies confirmed what previous genetic studies had suggested, and produced several surprises [6].

The incidence of congenital color blindness is different in various regions of the globe. For instance, 8% of adult males and 0.4% of adult females are color blind in western states. The prevalence of CVD is 4–6.5% in Japan and China, 4% in African countries, 7.3% in Turkey, and 2.9–11% in Saudi Arabia. Still, the prevalence of acquired color blindness varies according to occupation, sex, and age, and has been reported to be 5–20% in different studies [7].

Experiments using gene therapy is an effort to cure congenital red-green color blindness in nonhuman primates were performed on adult squirrel monkeys (*Saimiri sciureus*). In this species, as in many other New World primates, there is a single opsin gene on the X chromosome, but there is allelic diversity at the locus [8]. One allele encodes the equivalent to a human long-wavelength (L) opsin; another encodes the equivalent to a human middle-wavelength (M) opsin, and at least one allele encodes an opsin that gives rise to a photopigment that is spectrally intermediate between human L and M photopigments [9].

2. Material and Methods

This was a cross-sectional study conducted in Koya city, Hawler province, Kurdistan Region, Iraq. Koya city is situated northeast of Hawler province and is a city of coexistence of different cultural groups, religious beliefs, and factions. In this city, Muslim Kurds, and Christians are being together. It's population more or less than 113,000. The study had been conducted in four basic schools that were present in Koya city (Zheen, Zanst, Nawroz and Najibaxan). All pupils from four schools in grades 2-7 are included in the survey. Our main outcome measures were the detection of color vision deficiency, which was examined by using Pseudoisochromatic Ishihara color test. It is a fast method of screening color blinds from normal [10].

- a) The Ishihara book of 24 plates was caught parallel to the face at a length of 70 or 75cm from the student, vertical in the line of sight.
- b) The test was performed for the enrolled pupils in a schoolroom, which should be cleared up sufficiently by daylight.
- c) Each plate was awarded to the pupil for three to five seconds and they were requested to record the numbers. The student was requested to take the numbers seen on the test plates 1 to 17.
- d) An evaluation of the reading of plates 1 to 15 determines the normality or deficiency of color vision.

- e) If 13 or more plates are read precisely, the color vision considered as normal. If only nine or less than nine plates are read precisely, the color vision was considered as red-green deficient.
- f) The plates 16 and 17 are used to discriminate protan and deutan types of color vision deficiency.
- g) If the person is unable to read numerals, plates 18-24 are used and the winding lines between the two X's are drawn. Each tracing should be completed within ten seconds. In addition to this, other information is obtained like ethnicity, religion, the degree of relationship (consanguinity) between parents.

3. Results and Discussion

Overall of 400 students, including (206) male and (194) female students, their age ranged between 8-14 years, finished the study. The prevalence rate of the deficiency in four primary schools is 3.39% in males and 0% in females. The prevalence of CVD in the current study among males in Zheen School (5.66%) was similar to the findings observed in India (5.85%) [11]. Almost similar distribution of prevalence of CVD as compared to above findings from Zanst school (4.08%). In Najibaxan and Nawroz primary schools prevalence of CVD among males is 2% and 1.85% respectively (Table 1).

Ishihara plates can only be used to detect and classify red-green color vision deficiencies, which are the most common types of CVD. Ishihara test has a mean sensitivity of 96% and mean specificity of 98.5%, revealed good rates [12]. The CVD is inherited as an X-linked recessive disorder, males are affected more as compared to females. The females usually act as carriers [13]. Since CVD is a genetic condition, its occurrence differs from one geographical area to the other and from population to population.

Distribution of color blindness among students in this study, according to the gender, total number of 206 male students examined and color blindness is 7 (3.39%), total number of 194 female students examined and color blindness is 0 (0%). From Zheen school total number of 53 male students examined and number of students that has color blindness is 3 and the average is (5.66%), while female students have no color blindness 0 (0%). As we know that male is more affected than female. From Zanst school the total number of male students examined is 49 and color blindness is 2 (4.08%), in Nawroz school is 1 (1.85%) and in Najibaxan is 1 (2%) (Table 1).

Distribution of students, according to the gender, types and severity of color blindness in male deuteranopia is 7 (3.39%), in female is 0 (0%), protanopia in male is 0 (0%), in female is 0 (0%). protanomaly in male is 0 (0%) and in female is 0 (0%) (Table 2).

Table 1. Distribution of students, according to the gender of color blindness for each school.

Schools	No. of screened students		Color blindness n (%)	
	Male	Female	Male	Female
Zheen	53	55	3(5.66%)	0(0%)
Zanst	49	44	2(4.08%)	0(0%)
Nawroz	54	50	1(1.85%)	0(0%)
Najibaxan	50	45	1(2%)	0(0%)
Total	206	194	7(3.39%)	0(0%)

Table 2. Distribution of students, according to the gender, types and severity of color blindness.

Gender	No. of Screened students	Color blindness n (%)	Protanomaly n (%)	Deuteranomaly n (%)	Protanopia n (%)	Deuteranopia n (%)
Male	206	7(3.39%)	0(0%)	0(0%)	0(0%)	7(3.39%)
Female	194	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
Total	400	7(3.39%)	0(0%)	0(0%)	0(0%)	7(3.39%)

Table 3. Distribution of students, according to the gender and two separate age of color blindness.

Gender	No. of screened students		Color blindness n (%)	
	Age 8-10	Age 11-14	Age 8-10	Age 11-14
Male	92(44.66%)	114(55.339%)	2(2.1735%)	5(4.385%)
Female	115(59.278%)	79(40.721%)	0(0%)	0(0%)

Distribution of students, according to the gender and two separate age of color blindness, in males number of screened students aged between 8-10 years is 92 (44.66%), and the students that have color blindness is 2 (2.1735%), number of screened male students aged between 11-14 years is 114 (55.339%), while color blindness is 5 (4.385%). Number of screened female students aged between 8-10 years is 115 (59.278%), color blindness is 0 (0%), female screened students aged between 11-14 years is 79 (40.721%), color blindness is 0 (0%) (Table 3).

Congenital CVD is a common genetic disorder affecting many patients worldwide. It's a hereditary type recessive X-linked disorder and is, therefore, more prevalent in men than women [14]. This disease causes a marked limitation and disability in the patients and usually affects a considerable percentage of people depending on the population and its characteristics [15,16].

The results of our study showed prevalence of male students aged between 11-14 years is 55.34%, which is more than male students aged between 8-10 years is 44.66%. The prevalence of female students aged between 8-10 years is 59.28%, which is more than female students aged between 11-14 years is 40.72%. The prevalence of color blindness based on the separate school for each gender in Zheen School is 5.60%, in Zanst is 4.08%, in Nawroz is 1.85% and in Najibaxan is 2%. While the prevalence of female from each school is 0%, and the prevalence of male color blindness in Zheen School is more than other schools, it has 3 (5.66%) color blind students. The prevalence of color blindness in all schools for each gender, the total of male color blindness is 3.39%, female color blindness is 0%, male color blindness is higher than female because male is more affected.

Prevalence of color blindness based on the severity of each gender, male students that have severity of

deuteranopia is 3.39% and in female is 0%, male deuteranomaly is 0% and in female is 0%, male protanopia is 0% and in female is 0%, male protanomaly is 0% and in female is 0%. Because all students that were having color blindness, they were having severity of deuteranopia. Prevalence of color blindness based on the different ages for each gender, male students have color blindness aged between 8-10 years is 2.17%, in female is 0%, male students have color blindness aged between 11-14 years is 4.39%, in female is 0%. A strong point of our study is its large sample size as we evaluated exactly 400 people.

Therefore, our results are valid and have high generalizability. Moreover, our samples made it possible to include all age groups from 8-14 years into the study to assess the relationship between age and the prevalence of CVD, which has been evaluated in a few studies.

The type of CVD depends on whether it is congenital or acquired. Red-green deficiency is more common in patients with congenital CVD, and yellow-blue deficiency is more common in patients with acquired CVD. In our study, deuteranopia was the most common type of CVD with a prevalence of 3.39%. The association between age and CVD was another finding of our study. The odds of having CVD were lower in male color blind from 8-10 years (2.17%) and higher in 11-14 (4.39%) year age groups. A limitation of this study is the lack of differentiation between acquired and congenital CVD, which may itself explain some differences with the results of previous studies.

Some studies only reported the prevalence of congenital CVD and reported the prevalence of acquired and congenital CVD separately, which could lead to different results. There may be two reasons for the difference. The first is the test that was used to assess color vision. Most studies used the Ishihara's test, but the researchers used Farnsworth D-15 tests their results were similar to our study. The second reason which is more

important may be lack of differentiation between congenital and acquired cases, causing overestimation in the prevalence of CVD [17]. In conclusion, the prevalence of CVD was high in Zheen School, especially in males and students over 11-14 years of age.

In Kurdistan region different research showed different results to determine prevalence and incidence of color blindness, The incidence of color blindness varies from race to race and in different geographical area. Since there is no such report about the prevalence of color blindness in the Kurdistan region (North of Iraq), earlier work had been conducted to find out the incidence of color blindness among preliminary, secondary and college students of Erbil city, Kurdistan region – Iraq. Participant's (n=1856, 1275 males, 581 females, age group 7 to 25 years) color vision was tested by using Ishihara chart [18].

On the other hands, other researches conclude that the prevalence of Color Vision Deficiency in Shekhan city was 6.36% among males and 0.84% among females. The most common types of Color Vision Deficiency among males were deuteranomaly (10 cases), protanomaly (5 cases), deuteranopia (2 cases) and protanopia (1 case) [1].

4. Conclusions and Recommendation

In this study, the following is concluded:

- a. Color blindness is different between students from each school.
- b. From all schools can't find the prevalence of female color blindness.
- c. Color blindness affects males more than females.

And following are our recommendations for future research:

- a. Determine prevalence of color blindness from different schools in Koya city based on ethnicity.
- b. Sequencing of genes which are responsible for the color blindness in both genders.
- c. Using other tests instead of Ishihara plate test to find color blindness.

References

[1]. Khalaj, M., Barikani, A. & Mohammadi, M. (2014). Prevalence of Color Vision Deficiency in Qazvin. *Zahedan J. Res. Med. Sci.*, 16(1): 91-93.

[2]. Abdulrahman, M. (2017). Prevalence of Color Vision Deficiency among Students in Hajand and Amad High Schools in Shekhan City. *Kurdistan J. Appl. Res.*, 2(2): 84-88.

[3]. Curcio, C.A., Sloan, K.R., Kalina, R.E. & Hendrickson, A.E. (1990). Human photoreceptor topography. *J. Comp. Neurol.*, 292(4): 497-523.

[4]. Cruz, E.M., Cerdana, H.G.S., Cabrera, A.M.B. Garcia, C.B., Morabe, E.T.S. & Nañagas, M.L.R. (2010). Prevalence of color-vision deficiency among male

high-school students. *Philippine J. Ophthalmol.*, 35(1): 20-24.

[5]. Sajid, H.T., Bibi, A., Tariq, N., Sajjad, N., Umer, K., Ali M. & Iqbal, R. (2016). Incidence of Protanopia and Deuteranopia, Defects of Colour Vision in Quetta, Pakistan. *Pak. J. Zool.*, 48(4): 1045-1049.

[6]. Neitz, J. & Neitz, M. (2011). The genetics of normal and defective color vision. *Vision Res.*, 51(7): 633-51. doi: 10.1016/j.visres.2010.12.002.

[7]. Hashemi, H., Khabazkhoob, M., Pakzad, R., Yekta, A., Heravian, J., Nabovati, P. & Ostadimoghaddam, H. (2019). The prevalence of color vision deficiency in the northeast of Iran. *J. Curr. Ophthalmol.*, 31(1): 80–85. doi: 10.1016/j.joco.2017.05.005.

[8]. Bunce, J.A., Isbell, L.A., Neitz, M., Bonci, D., Surridge, A.K., Jacobs, G.H. & Smith, D.G. (2011). Characterization of opsin gene alleles affecting color vision in a wild population of titi monkeys (*Callicebus brunneus*). *Am. J. Primatol.*, 73(2): 189–196. doi: 10.1002/ajp.20890.

[9]. Jacobs, G.H., Neitz, J. & Neitz, M. (1993). Genetic basis of polymorphism in the color vision of platyrrhine monkeys. *Vision Res.*, 33(3): 269–274. doi: 10.1016/0042-6989(93)90083-9.

[10]. Ishihara, S. (2007). The series of plates designed as a test for color deficiency. 24 plates edition. Kanehara Trading Incorporated, Tokyo, Japan.

[11]. Shah, A., Hussain, R., Fareed, M. & Afzal, M. (2013). Prevalence of Red-Green Color Vision Defects among Muslim Males and Females of Manipur, India. *Iran J. Public Health*, 42(1): 16–24.

[12]. Mehari, Z.A. & Yimer, A.W. (2013). Prevalence of refractive errors among schoolchildren in rural central Ethiopia. *Clin. Exp. Optom.*, 96(1): 65–69. doi: 10.1111/j.1444-0938.2012.00762.x.

[13]. Hall, J.E. (2010). Guyton and Hall Textbook of Medical Physiology. 12th ed. Saunders, Philadelphia.

[14]. Birch, J. (2012). Worldwide prevalence of red-green color deficiency. *J. Opt. Soc. Am. A*, 29(3): 313–320. doi: 10.1364/JOSAA.29.000313.

[15]. Niroula, D.R. & Saha, C.G. (2010). The incidence of color blindness among some school children of Pokhara, Western Nepal. *Nepal Med. Coll. J.*, 12(1): 48–50.

[16]. Saito, A., Mikami, A., Hasegawa, T., Koida, K., Terao, K., Koike, S., Onishi, A., Takenaka, O., Teramoto, M. & Mori, Y. (2003). Behavioral evidence of color vision deficiency in a protanomalial chimpanzee (*Pan troglodytes*). *Primates*, 44(2): 171–176. doi: 10.1007/s10329-002-0017-5.

[17]. Jafarzadehpur, E., Hashemi, H., Emamian, M. H., Khabazkhoob, M., Mehravaran, S., Shariati, M. & Fotouhi, A. (2014). Color vision deficiency in a middle-aged population: the Shahroud Eye Study. *Int. Ophthalmol.*, 34(5): 1067–1074. doi: 10.1007/s10792-014-9911-2.

[18]. Karim, J.K. & Salem, M.A. (2013). Prevalence of congenital red-green colour vision defects among various ethnic groups of students in Erbil City. *Jordan J. Biol. Sci.*, 6: 235–238. <http://dx.doi.org/10.12816/0001540>.