

COMPARATIVE REVIEW OF COLOR BLINDNESS IN DIFFERENT ETHNIC POPULATIONS

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ABSTRACT: Color blindness is a hereditary disorder of colour vision, found almost exclusively in males, transmitted by sex-linked recessives by two pairs of genes in the non-homologous part of the X chromosome. The current study provides data on the prevalence of impaired color vision from seven studies in different ethnic populations. These include Tibetan, Jordanian Muslims, Turkish men and Nepali and Singaporean school children. The importance of identifying individuals with color vision defects is to ensure that adequate provision and advice is given, especially in relation to their education and career choice.

KEYWORDS: Color blindness, Hereditary disorder, Ethnic populations, Tibetans

INTRODUCTION: The faculty by which one can distinguish between different colors and color tones as excited by light of different wavelengths is known as Color Sense. Sir John Dalton first gave a clear description of his own color blindness in 1794. His publication subsequently stimulated much research into the pathophysiology and genetics of the condition (1). In 1801-1802 Thomas Young postulated the existence of three 'Principal' colors (Red, Green and Violet), from which all colors and white light can be obtained (2). Von Helmholtz (1866) suggested that there are three types of cones, containing three photochemical substances corresponding to the three fundamental color sensations (3). Von Kries (1923) noted that anomalous Trichromats can see all the three colors, but the appreciation of one particular color is subnormal. He further described Protanomaly as sub-normal green vision and Tritanomaly as sub-normal blue vision. People who can see two colors but fail to see the third are designated as Dichromats. Dichromats lack red pigment gene and those lacking green pigment gene are known as Protanopes while those lacking blue green pigment are known as Tritanopes (4). In 1881, Lord Rayleigh introduced anomaloscope for scientific analysis of color defects (5).

Color blindness is a hereditary disorder of color vision, being transmitted by sex-linked recessives by two pairs of genes in the non-homologous part of the X chromosome. It is much more common in males than in females. Y-chromosome plays no role in the determination of color vision (6). The objective of the present article is to correlate the prevalence of colorblindness in various groups of ethnic populations. People with defective color vision are at a disadvantage especially for employment in defense services, technical fields like engineering, medical profession, textile industry, dyeing industry, pilots, drivers etc. This may influence their education and carrier choice.

MATERIAL AND METHODS: Seven studies were identified that examined the prevalence of color vision impairment. These studies are summarized in the table 1. Some of the percentages included in this table were calculated by the author of this report. The prevalence of color blindness was assessed in Tibetans, Turkish men, Jordanians, Singaporean children and Nepali school children & two other populations. Ishihara Pseudoisochromatic test plates were used for these populations

while HRR (Hardy, Rand and Ritter) Pseudoisochromatic test plates were used in assessing male population of Lalima village, Terena, India. In addition, Pickford Nicolson anomaloscope was used in the Tibetan study used to distinguish the type and the extent of defect of color vision.

Ishihara plates consist of a series of cards in which a colored background is printed in spots of different sizes (7). A letter, figure or a number is printed against this background in spots of the same size. To a normal subject, the figure or letter at once becomes clear, but the color blind subject fails to distinguish it from the background. It is easy, quick to perform and type of color defect can be ascertained with a fair degree of accuracy. The detection of Tritan defect is not possible using this test. The Pickford Nicolson Anomaloscope is a simple colorimeter based on the use of integrating boxes which has color chance's optical glass filters. The wavelengths of the primary filters (red and green) used are 642nm and 555nm, to produce a yellow with a wavelength of 585nm. It is manually operated. It is the only instrument by means of which colour blindness can be correctly classified (8).

RESULTS AND DISCUSSION: The present article provides a met analysis the prevalence of impaired color vision from 7 different studies in diverse populations.

The prevalence of color blindness in the Tibetan male population (n=120) was 4.21%. No Tibetan female was found to be color blind (9). The prevalence of color blindness in the Tibetan males was lower than that reported in Turkish men (7.33%) (10) and Jordanian men 8.7% (11). On the other hand the prevalence of color blindness in the males in the Tibetan population was much higher than that reported in the Indian population of Lalima village, Terena 0 % (12). Strikingly, the prevalence of color blindness in the Tibetan male population is in accord with those in Nepali school children 3.8% (15) (S.D. $\pm 0.4\%$) (13). The prevalence of color blindness in Singaporean children was assessed and found it to be 5.3% (SD $\pm 0.9\%$) (14) while found it to be 5.42% in Southern Calabria (variation $\pm 1.2\%$) (15). In the Muslim communities, consanguineous marriages are very common with more likelihood of transmission of hereditary disease. Consanguineous marriages also take place in Tibetan and Nepali communities but the frequency is quite low compared to Muslim community. This explains a lesser incidence of color blindness in the Tibetans and Nepalese compared with the Turkish and Jordanian groups.

None of the females was found to be color blind in the Tibetan, Turkish populations and Nepali school children (9,10,13) while the incidence in Jordanians was reported 0.33% (12) and 0.2% in Singaporean children (14).

The reason for the wide variation of frequency in the two sexes can be explained on the basis of heredity of color vision defects. Red and green defects in color vision are transmitted as sex-linked recessive by two pairs of genes in the non-homologous part of the X-chromosome, each of which might mutate into one of the 3 different alleles. The incidence of color blindness in females is much less compared with males because a female must carry a pair of homologous abnormal genes which however is rare. This explains very low frequency of color blindness in females (6). As color blindness is a congenital defect, its incidence does not have any relation with age.

The Tibetan study (9) showed 14 (n=14) cases simple Deuteranomaly, 8 Extreme Deuteranomaly followed by 9 cases of Protanopia, 9 Deuteranopia, 7 Protanomaly, 3 Extreme Protanomaly and 1 case of Tritanopia. The Jordanians (Al Aqtum and Al Qawasmeh (2001) had 8 cases of Deuteranomaly, 4 Deuteranopia, 4 Protanomaly and 3 cases of Protanopia and 4 of deuteranopia. Strikingly in these 2 studies Deuteranomaly is the predominant finding followed by

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Deuteranopia. [Table 2]. However, the study in Nepali school children showed the maximum number of cases of Deuteranopia (n=9), followed by Deuteranomaly 6, Protanomaly 3 (13). Among the anomalous trichomats the frequency of Deutern anomaly is more than that of protanomaly. This could be explained by genetic factors (16). Males with normal color vision always have one red pigment gene. However the number of green pigment genes differs among those individuals and ranges between 1 and 3. Most people have 2 green pigment genes. Larger number of genes for the green pigment explains the higher frequency of Deuteranomaly as compared with protanomaly (17).

SUMMARY AND CONCLUSION: The percentage distributions of color blindness in our studies were found different in different

Ethnic populations: highest in Jordanian men [8.7%] followed by Turkish men [7.33%]. Since Color blindness is genetically transmitted, its distribution varies from race to race and is different in the different geographical regions of the world inhabited by people of different ethnicity.

The prevalence of Deuteranomaly was highest among different male ethnic populations and that of Tritanopia was the lowest. Although several therapies have been proposed [eg. Electrical eye stimulation, Iodine injections, Large doses of vitamins], there are no treatments or surgical procedures to improve the quality of an individual's chromatic vision. The natural history of color vision impairment cannot be altered, the importance of identifying individuals with color vision defects is to ensure that adequate provision and advice is given.

It may be concluded that the major benefit of color vision screening is to ensure adequate carrier advice. It would also be interesting to genetically examine the various populations and verify the genes that code for photo pigments.

Reference	Colour vision test	Sample size	Results
(Navjot et al 2011)	Ishihara charts Pickford Nicolson Anomaloscope	n = 2010 Males = 1210 Females = 800	Males = 4.21% Females = 0%
(Citirik et al, 2005) Turkish men	Ishihara charts	Males= 941 Females = 0	Males= 7.33±0.98% Females= 0%
(Chia et al., 2008) Singaporean Children	Ishihara charts	n = 1249	Males= 5.3% Females= 0.2%
Al-Aqtum and (Al-Qawasmeh 2011) Jordanians	Ishihara charts	n = 1418 Males = 218 Females= 1200	Males= 8.7% Females= 0.33%
(Niroula and Saha 2010) Nepali School Children	Ishihara charts	n = 964 Males = 474 Females= 490	Males= 3.8% Females = 0%
(Tagarelli et al., 2000) Italian population	Ishihara charts	n = 13,072 (Males)	n = 5.42%
(Piccinin et al., 2010) Indian population	HRR - Pseudoisochromatic plate test	n = 226 Males	n = 0%

Table 1: Summary of studies examining the prevalence of colour blindness

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PERCENTAGE DISTRIBUTION OF TYPES OF COLOR BLINDNESS IN DIFFERENT POPULATIONS

Different Ethnic Populations	Total number of males	Number of Colour blind males	Trichomatism		Dichromatism		
			Protanomaly	Deuteranomaly	Protanopia	Deuteranopia	Tritanopia
Tibetans [Navjot et al 2009]	1210	51	19.6%	43.13%	17.64%	17.64%	1.96%
Jordanians [Al Aqtum & AlQuawasmeh 2001]	218	23	17.39%	34.78%	13.04%	17.39%	0%
Nepali school children [Niroula & Saha 2010]	474	18	17%	33%	0%	50%	0%

COMPARISON TABLE - COLOUR BLINDNESS

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